Identification of Palatal Rugae in Maxillary Anteroposterior Dysplasia

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CERTIFICATE

This is to certify that the dissertation titled **"Identification of Palatal Rugae in Maxillary Anteroposterior Dysplasia"** done by **Dr. PREETI PRABHAKARAN,** Postgraduate student (M.D.S), Orthodontics (branch V), Tamil Nadu Government Dental College and Hospital, Chennai, submitted to the Tamil Nadu Dr. M.G.R. Medical University in partial fulfillment for the M.D.S. degree examination (April 2015) is a bonafide research work carried out by her under my supervision and guidance.

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DECLARATION

I, **Dr. PREETI PRABHAKARAN**, do hereby declare that the dissertation titled **"Identification of Palatal Rugae in Maxillary Anteroposterior Dysplasia"** was done in the Department of Orthodontics, TamilNadu Government Dental College & Hospital, Chennai 600003. I have utilized the facilities provided in the Government Dental College for the study in partial fulfillment of the requirements for the degree of Master of Dental Surgery in the specialty of Orthodontics and Dentofacial Orthopedics (Branch V) during the course period 2012-2015 under the conceptualization and guidance of my dissertation guide, **Prof. Dr. SRIDHAR PREM KUMAR, M.D.S,**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s)

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Signature of the Head of the Institution

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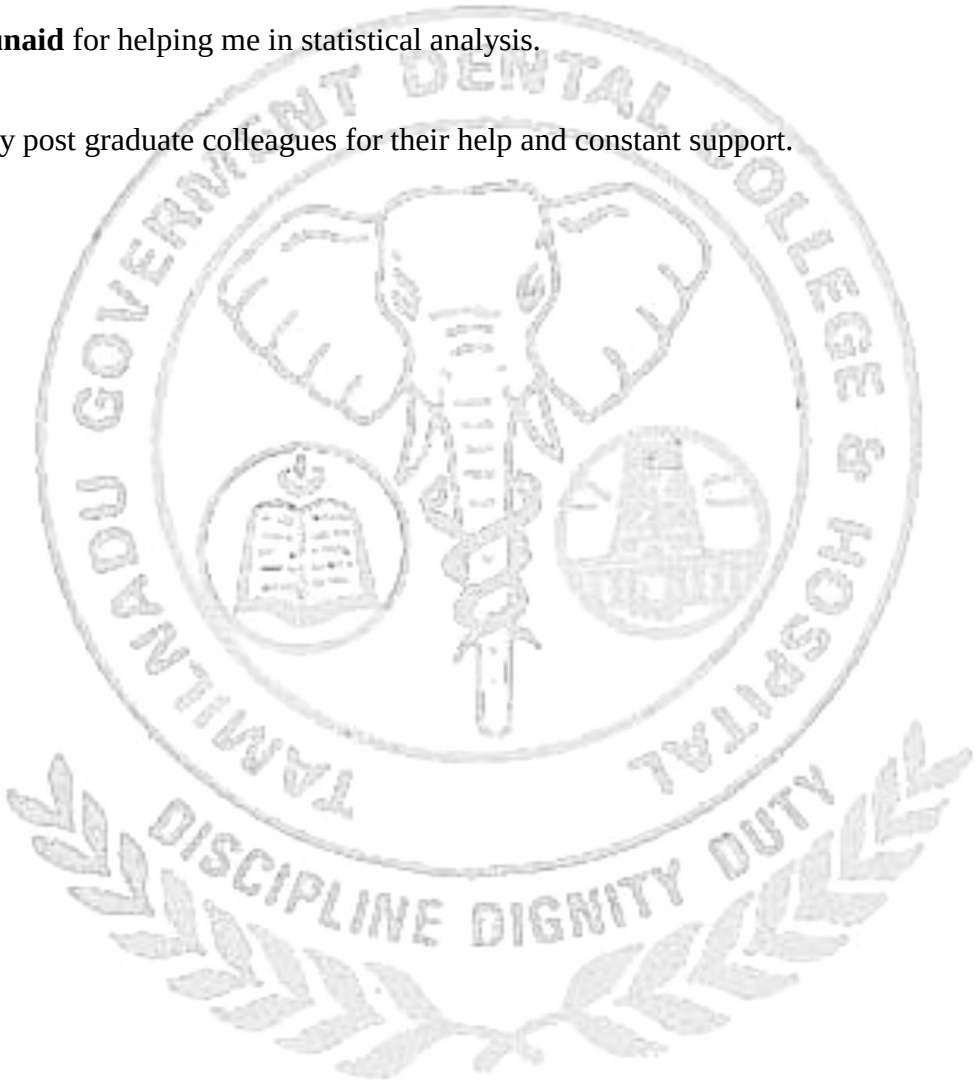

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This agreement herein after the "Agreement" is entered into on this..... day of December 2014 between the Tamil Nadu Government Dental College and Hospital represented by its **Principal** having address at Tamilnadu Government Dental college and Hospital, Chennai-03, (hereafter referred to as , 'the college')

And

Dr. SRIDHAR PREMKUMAR aged 47 years working as professor in the Department of Orthodontics and Dentofacial orthopaedics, at the college, having residence address at B-3, Block 2, Jains Ashraya Phase III, Arcot road, Virugambakkam, Chennai-92. (herein after referred to as the 'Principal investigator')

And

Dr. PREETI PRABHAKARAN aged 30 years currently studying **M.D.S (Orthodontics)** in Tamilnadu Government Dental college and Hospital (herein after referred to as the 'PG/Research student and co- investigator').

Whereas the 'PG/Research student as part of his curriculum undertakes to research **"*Identification of Palatal Rugae in Maxillary Anteroposterior Dysplasia*"** for which purpose the PG/Principal investigator shall act as principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator.

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard.

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9. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

In witness whereof the parties hereinabove mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its

Principal **PG Student**

Witnesses **Student Guide**

1.

2.

ABSTRACT

Background: - Numerous studies have correlated palatal rugae with ethnicity, gender and orthodontic treatment and its uniqueness has been established. No studies in literature yielded a relationship between palatal rugae and the size of maxilla. So an attempt was made to evaluate the relationship between palatal rugae and maxillary anteroposterior dysplasia.

Aim and objectives: - To determine the uniqueness of palatal rugae pattern, by comparing them among orthognathic, retrognathic and prognathic maxilla.

Materials and methods: - 90 samples in the age group of 15-25yrs with orthognathic mandible were chosen and grouped into orthognathic maxilla group(30 samples), prognathic maxilla group(30 samples) and retrognathic maxilla group(30 samples). The palatal rugae pattern for each group were recorded and assessed for their number, size and shape. The data were tabulated and statistically analyzed. Finally results were compared among the three groups.

Results: - The number of rugae on the right side of the maxilla showed significant differences among the three groups. Group with prognathic maxilla and retrognathic maxilla had shown high propensity for 4 rugae with 63.3% and 53.3% of the total sample respectively when compared to orthognathic maxilla which showed this propensity in only 23.3% of the total samples. Orthognathic maxilla had shown high propensity for 5 rugae in 26.7% of the total sample when compared to prognathic (6.7%) and retrognathic maxilla (3.3%). Wavy pattern was the most predominant shape but this was not statistically significant. No statistically significant differences were found with respect to the size of rugae and the size of maxilla.

Summary and Conclusion: - This study identified variations in distribution of various palatal rugae pattern in three groups. The number of rugae was found to be statistically significant on right side of the maxilla. Though different types of anteroposterior dysplasia are more prone to have a specific type of rugae pattern, future studies are still needed to further validate this study.

Key words :-palatal rugae, rugae pattern, maxillary anteroposterior dysplasia, rugoscopy,

Contents

ABBREVIATIONS

PR	Palatal Rugae
CRL	Crown Rump Length
APD	Anteroposterior Dysplasia
PRCS	Palatal Rugae Comparison Software
AA	Australian Arborigines
E.g.	Example
WA	Wavy
CU	Curved
ST	Straight
DIV	Diverging
CON	Converging
CI	Circular
%	Percentage
&	And
Vs.	versus
R1	First Rugae
R2	Second Rugae
R3	Third Rugae
R4	Fourth Rugae
R5	Fifth rugae

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INTRODUCTION

Palatal rugae (PR) or transverse palatine folds refer to the irregular elevations of the mucous membrane extending laterally from the incisive papilla and the anterior part of the median palatal raphe located in the mid-sagittal plane. Goria [1]defined the rugae as the ridges that extend at least one-half the distance from the median palatal raphe to the dental arch.

Formation of a rugae pattern takes place by the 12th to 14th week of intrauterine life from the connective tissue covering the palatine process of the maxillary bone[2]. The growth and development of rugae is controlled by epithelial-mesenchymal interactions, where specific extracellular matrix molecules are expressed during development[3]. The first ruga is distinguished in human embryos of 32 mm CRL[4] next to the incisive papilla. PR are relatively prominent in the prenatal stage**.** At birth, they are well trained with a typical orientation pattern[5,6] and the final shape will be acquired in adolescence[7]. Once formed, they may experience changes in their size due to growth of the palate, but the shape remains maintained[8,9].

Histologically, the rugae are stratified squamous, mainly para keratinized, epithelium on a connective tissue base, similar to the adjacent tissue of the palate[10]**.** The core fibres running anteroposteriorly in concentric circles below each rugae govern the orientation and forms of palatal rugae. Fibroblasts and collagen fibres then accumulate in the connective tissue beneath the thickened epithelium and assume distinct orientation. The core within the palatal rugae of humans contains elements that are believed to contribute to the maintenance of its shape. Glycosaminoglycans are the main

structural element of rugae which by its hydrophilic nature causes the tissue to swell and contributes to the maintenance of the shape of rugae throughout life.[11]

Physiologically the palatal rugae are involved in the oral swallowing and help to improve the relationship between food and the taste receptors on the dorsal surface of the tongue[4]**,** also participate in speech and in the suction in children[12].

These rugae have significant characteristics features as they are unique patterns in each individual and remain stable from the time of development until death. These asymmetric and irregular ridges are well protected by the lips, cheek, tongue, buccal pad of fat and teeth in incidents of fire and high-impact trauma. They even reappear after trauma or surgical procedures. Studies have reported that most burn victims with panfacial third degree burns did not sustain any palatal rugae pattern changes, and when changes were noted, they were less pronounced than the generalized body state[13]. Rugae have been used in medico-legal identification processes because their individual morphological characteristics are stable over time.

However, some events may contribute to changes in the pattern of PR, such as finger sucking in childhood and persistent pressure due to orthodontic treatment[14]. Furthermore, it has been reported that extractions can produce a local effect on the direction of the PR[15]**.**

CLASSIFICATION OF THE PATTERN OF PALATAL RUGAE

Winslow[16] seems to have been the first to describe PR, and the earliest illustration of PR probably is by Santorini[17] a drawing depicting three continuous wavy lines that cross the midline of the palate. The first classification was developed by Goria in 1911[18]. Carrea[19],

Thomas and Kotze[20], Kapali et al[14] have also given their contributions in this field. Among the different classifications, classification given by Thomas and Kotze and kapali et al are the most accepted ones.

Shape- The authors have categorized shape of the rugae as 'straight', 'wavy', 'curved' and 'circular'. In addition, if a ruga has two arms, it is categorized as 'unification'. Thomas and Kotze[20] have categorized unification type as 'converging' or 'diverging', depending upon the type of origin.

• Straight type runs directly from their origin to termination in a straight line.

• Curved type has a simple crescent shape which curves gently. Evidence of even the slightest bend at the termination or origin of a ruga leads to a classification as curved.

• Wavy type—the basic shape of the wavy rugae is serpentine; however, if there is a slight curve at the origin or termination of curved rugae it is classified as wavy.

• Circular type to be classified as circular, a ruga needs to display a definite continuous ring formation.

- Unification type occurs when two rugae are joined at their origin or termination. Unifications in which two rugae begin from the same origin medially but immediately diverge towards lateral are classified as diverging and those which origin from two different origins medially and then converge laterally are classified as converging.

Length - Thomas and Kotze[20] classified rugae based on their length as:

- Primary rugae >5mm
- Secondary rugae- 3 to 5mm
- Fragmentary rugae < 3mm

Rugae less than 2mm were disregarded.

Palatoscopy or Palatal rugoscopy is the name given to the study of palatal rugae in order to establish a person's identity[21]. Palatal rugoscopy is based on the principle that no two palates are the same**.** The study of palatal rugae, finds application in the field of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics and orthodontics.

There are different studies which document relationship of PR with ethnicity[22], gender[23], and changes after orthodontic treatment in different malocclusion[24].

Searching the orthodontic literature did not yield any study which correlated the palatal rugae with the size of maxilla. Since the literature is silent in this facet of Orthodontics, this study was initiated with an aim to evaluate relationship of rugae with different maxillary anteroposterior dysplasia.

AIM OF THE STUDY

To determine the uniqueness of palatal rugae pattern in orthognathic, retrognathic and prognathic maxilla.

OBJECTIVES OF THE STUDY

- To assess the size, shape and number of rugae in subjects with orthognathic maxilla.
- To assess the size, shape and number of rugae in subjects with prognathic maxilla.
- To assess the size, shape and number of rugae in subjects with retrognathic maxilla.
- Compare the rugae pattern among the three groups.

PALATAL RUGAE (PR) MORPHOLOGICAL & HISTOLOGICAL ANATOMY

Gegenbaur,1878[5]**,** stated that PR in the prenatal stage are relatively prominent and attains typical orientation pattern at birth which remains stable throughout the person's life.

Carrea JU, 1937[2] indicated that formation of a rugae pattern takes place by the 12th to 14th week of prenatal life.

Lysell L, 1955 [25]considered that the number of rugae decreased from 23 years of age onwards. Some events can contribute to changes in rugae pattern, including trauma, extreme finger sucking in infancy, and persistent pressure with orthodontic treatment and dentures. .He suggested that changes in the length of rugae with age result from underlying palatal growth.

Yamazaki, 1962 [7] stated that the final featured shape of PR in each individual is acquired by adolescence .

Peavy &Kendrick, 1967[15] found that form, layout and characteristics are not affected by the eruption of the teeth or their loss, but sometimes palatal rugae adjacent to the alveolar arch slightly change their position after tooth extraction.

Jordanov, 1971 [8]**,** stated once PR are formed may experience changes in their size due to growth of the palate, but its shape is maintained.

Van der Linden FP, 1978 [26] proved that the anterior rugae do not increase in length after 10 years of age.

Simmons JD et al,1987[27] stated that it was noted that rugae count decreases significantly following cleft repair and median rugae region increases in antero-posterior length with growth. These changes being more obvious in orthodontically treated cases.

English WR et al,1988 [11] stated that there are the core fibres running anteroposteriorly in concentric circles below each rugae which govern the orientation and forms of palatial rugae. Beneath the thickened epithelium fibroblasts and collagen fibres then accumulate in the connective tissue and assume distinct orientation. The core within the palatal rugae of humans contains elements that are believed to contribute to the maintenance of its shape. Glycosaminoglycans are the main structural element of the rugae which by its hydrophilic nature causes the tissue to swell and contributes to the maintenance of the shape of a rugae throughout life.

Hauser G et al,1989 [28] have suggested that the mean ruga count changes moderately in adolescence and then increases markedly from the age of 35 to 40 years.

Almeida et al., 1995[24] stated that the PR form elevations more or less prominent and take various configurations. Its design and structure are unchanged and are not altered by chemicals, heat, disease or trauma, or, if palatal rugae are destroyed, are reproduced exactly on the same site that had.

Almeida MA et al,1996[29] concluded that movement of teeth may change the position of the rugae points, supported by **Abdel-Aziz HM, Sabet NE 2001.**[30]

Kapali S et al,1997 [14] stated that some events can contribute to changes in rugae pattern including trauma, extreme finger sucking in infancy, and persistent pressure with orthodontic treatment.

Amasaki H et al., 2003 [3] stated that palatal rugae appear during the third month of intrauterine life from the connective tissue covering the palatine process of the maxillary bone. The growth and development are controlled by epithelial-mesenchymal interactions, where specific extracellular matrix molecules are spatiotemporally expressed during development.

Caldas IM et al. 2007[21]stated that the Palatal rugae (PR) or Transverse palatine folds are asymmetrical and irregular elevations of the mucosa in the anterior third of the palate, arranged in a transverse direction from the palatine raphe located in the mid-sagittal plane.

Nayak P et al,2007 [31] stated that rugae develops as localized regions of epithelial proliferation and thickening.

RUGOSCOPY

Harrison Allen in 1889[32] gave the first suggestion for the use of palatal rugae as a method of personal identification.

Trobo Hermosa in 1932[33]**,** a Spanish investigator was the first to propose the term " Palatal rugoscopy". It is the study of palatal rugae in order to establish a person's identity.

Limson & Julian,2004[34] compared some points of the rugae patterns using computer software & found that the percentage of correct matches ranged from 92‑97%. They stated that the PR has been considered relevant for human identification due to its stable nature, being equivalent to the fingerprint, unique for each individual.

Acharya AB et al,2006 [35] stated that the study of palatal rugae, finds application in the field of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics and orthodontics, is termed as Rugoscopy.

METHODS TO ASSESS RUGAE[36]

Different methods to assess rugae have been identified which are used according to the requirements of the study. They are as following-

- **Intra-oral examination:** Most commonly used technique. Rugae anatomy like number and shape are assessed based on different classifications given by different authors.

  Advantages: Easy to perform and cost effective

  E.g. Rugae categorized as Principal rugae and Accessory rugae.

  Rugae shape will be categorized into -

  A 1 Point

  B 2 Line

  C 3 Angle

  D 4 Sinuous

  E 5 Curve

  F 6 Circle

  X 7 Polymorphic

  Disadvantages: No records exist with this method which makes future comparison difficult.

- **Photographs and Impression of maxillary arch:**

  Advantages: Futures comparisons can be made, easy to perform and cost effective.

- **Computer software programs:**

  Superimposition of various digital photographs for comparing rugae pattern can be performed using various computer softwares e.g, , Palatal Rugae Comparison Software

  (PRCS Version 2.0).

- **Calcorrugoscopy or Overlay print:**

  Can be used to perform comparative analysis

- **Stereoscopy:**

  Can be used to obtain the 3- dimensional image of palatal rugae anatomy.

- **Stereophotogrammetry:**

  Allows for an accurate determination of length and position of every single palatal rugae.

CLASSIFICATION

1. The first palatal classification system was put forth by **Goria** in **1911.**[18,36]

The rugae pattern was divided into two types-

- Specifying the number of rugae
- Specifying the extent of rugal zone relative to the teeth

- Further distinguished rugae into 2 types-
- Simple or Primitive
- More developed

2. By **Trobo (1932)** [33,36] **:**

Palatal rugae were divided into two groups:

- **Simple rugae:** Where rugae shapes are well defined and divided further as Type A, B, C, D, E, F

Classification Rugae type

Type A : Point

Type B : Line

Type C : Curve

Type D : Angle

Type E : Sinuous

Type F : Circle

- **Compound rugae:** Rugae are formed by the union of two or more simple rugae and were classified as

"Type X" or Polymorphic type.

3. Da Silva Classification (1938) [21, 36] :

Based on **shape** , Palatal rugae classified into two types-

- **Simple:** Numbered from 1-6

Classification Rugae type

1 Line

2 Curve

3 Angle

4 Circle

5 Wavy

6 Point

- **Composed:** Resulting from combination of 2 or more rugae patterns

4. According to **Lysell (1955)**[37,36] :

Palatal rugae were classified depending on **its length**

- Primary: 5mm or more
- Secondary: 3-5mm
- Fragmentary: 2-3mm
- Rugae smaller than 2mm are disregarded

5. Carrea classification (1955) [21,36]:

Based on **form** of the palatal rugae-

Type I: Posterior-Anterior directed rugae

Type II: Rugae perpendicular to raphe

Type III: Anterior-Posterior directed rugae

Type IV: Rugae directed in several directions

6. Martins dos santos classification[21,36] **:**

Based on **form and position** of each palatal rugae-

One initial rugae; the most anterior one on the right side is represented by a capital letter

Several complementary rugae; the other right rugae are represented by numbers

One subinitial rugae; the most anterior one on the left side is represented by a capital letter

Several subcomplementary rugae; the other left rugae are represented by numbers

7. Basauri Classification[21,36]**:**

It differentiates between the principal rugae, which is the more anterior one (labeled with letters) and the accessory rugae, which consists of all the remaining rugae (labeled with numbers). The rugogram is elaborated beginning from the right side of the palate.

8. By **Kapali et al(1997)**[14,36]

Based on **shape** of Palatal rugae

- Curved
- Wavy
- Straight
- Circular

9. Modification **of Kapali's** classification[38,36] **:**

- Converging
- Curved
- Wavy
- Straight
- Circular
- Furcated

10. Thomas and Kotze classification (Most accepted classification) (1983)[20,18,36]:

Proposed detailed classification consisting of the following—

- **Rugae dimension and Prevalence**-
  - Length- determined according to the latest rugal dimension and is classified as Primary, Secondary and Fragmentary rugae.
  - Prevalence-Rugae is determined by counting and recording the number in each category (Primary, Secondary and fragmentary) and not the total number on each side.
  - Area- determination of the surface area of primary rugae

- **Primary rugae details**-

- These can be described as annular, papillary, crosslink, branches, unification, breaks, unification with non-primary rugae.

- **Rugae pattern dimensions-**

- Distance between most anterior point on incisive papilla and most anterior point on rugae pattern regardless of the side.
- Distance between incisive papilla to posterior border of last primary or secondary rugae.
- Distance between incisive papilla to posterior border of last rugae (including fragmentary).

- **Angle of Divergence-**

- Measured in degree between the line formed by the medial palatal raphe and line joining incisive papilla with the origin of most posterior primary or secondary rugae on one side of the palate.

- **Dental arch and palate dimensions-**

- ***Width***- Line joining the tips of mesiopalatal cusp of permanent maxillary first molar or the deciduous second molar is used to project a point below and perpendicular to it on the gingival margin to determine the width.
- ***Depth***- point below and perpendicular to line joining the tips of mesiopalatal cusp of maxillary permanent first molar or the deciduous second molar on the mid-palatal raphe is used to determine the depth.

- ***Centre***- Perpendicular distance between the line joining the tips of mesiopalatal cusp of maxillary permanent first molar or the deciduous second molar and the point on the midpalatal raphe determines the center.

11. Rugae unification pattern classification[39,36] **:**

- Converging
- Diverging

12. Classification based on orientation of rugae in relation to mid palatal raphe[4036]**:**

- Forward
- Right angle
- Backward

CLINICAL SIGNIFICANCE

PALATAL RUGAE AND FORENSIC IDENTIFICATION

Establishment of person's identity can be a difficult task in cases of traffic accidents or acts of terrorism or in mass disaster situations. Visual identification, use of dental records and fingerprints and DNA comparisons probably are the most common techniques used in this context, allowing fast and secure reliable identification. However, visual identification and use of fingerprints are limited by postmortem changes associated with time, temperature and humidity.

Allen in 1889[32] suggested the application of palatal rugae patterns for personal identification.

Lysell,1955[16] **as well as Sassouni ,1957**[41] believed that, in general, the palatal rugae are unchanged throughout life, but found that this does not apply in every aspect. In older subjects, there is an evident reduction in the number of rugae. The age change was also stressed by **Dahlberg AA,1963**[42].

Sassouni, 1957[41]stated that it is possible to devise a classification based on the symmetry, number and shape of papillae. When he tested the classification, he was able to identify a person without difficulty. The palatal rugae can be used in the same way as fingerprints; however, as the rugae are composed only of soft tissue, they are not present in skeletons.

Fiene,1958[43] discovered that the palatal rugae could be helpful in anthropological paternity investigations.

Peavy DC, Kendrick GS, English et al 1967[15] noted that the characteristic pattern of the palatal rugae did not change as a result of growth, remaining stable from the time of development until the oral mucosa degenerated at death.

Morlang WM,1982[44] stated that although teeth are more durable than other parts of the body, identification via dental records also may prove to be inconclusive, because dental treatment might have been performed between the creation of a dental record and the person's death. Although DNA profiling is accurate, it is expensive and time consuming for use in large populations. It is a well-established fact that the rugae pattern is as unique to a human as are his or her fingerprints and it retains its shape throughout life. The anatomical position of the rugae inside the mouth are surrounded by cheeks, lips, tongue,

buccal pad of fat, teeth and bone which keeps them well-protected from trauma and high temperatures. Thus, they can be used reliably as a reference landmark during forensic identification.

Brinon, 1983[10,45] following the studies of **Carrea**, divided palatal rugae into two groups (fundamental and specific) in a similar way to that done with fingerprints. In this manner, dactyloscopy (study of fingerprints) and palatoscopy (study of palatal prints) were united as similar methods based on the same scientific basis. The two systems are sometimes complementary: for instance, palatoscopy can be of special interest in those cases where there are no fingers to be studied (burned bodies or bodies in severe decomposition).

English WR, Robison SF etal,1988 [11] stated that the Visual identification is the most common method; because most deaths do not occur under unusual circumstances, the remains are usually visually identifiable. However, in complex identification, visual means of identification is the least desirable method because of emotional stress in the identifier and lack of objective assessment at the time of identification. The Rugae have been used in medico-legal identification processes because their individual morphological characteristics are stable over time. Also qualitative characteristics such as shape, direction and unification remain stable throughout life.

Thomas CJ and Van Wyk CW,1988[46] successfully identified a severely burnt edentulous body by comparing the rugae to the pattern on the victim's old denture; this indicates, among other things, that rugae are stable in adult life. Thus, palatal rugae appear to possess the features of an ideal forensic identification parameter, i.e., uniqueness, postmortem resistance, and stability.

Fahmi et al (2001)[47] reported that no two palates are alike in their configuration. Even between twins, the patterns are not identical. No two palates are alike in their configuration. Thus, palatal rugae appear to possess the features of an ideal forensic identification parameter, i.e. uniqueness, postmortem resistance and stability, provided antemortem record exists.

Limson KS, Julian R 2004[34] undertaken a study to determine the thermal effects and the decomposition changes on the palatal rugae & concluded that the most burn victims with panfacial third degree burns did not sustain any palatal rugae pattern changes, and when changes were noted, they were less pronounced than the generalized body state.

Muthusubramanian M etal,(2005)[13]did a study to examine the extent of palatine rugae preservation for use as an identification tool in burn victims and cadavers, thus simulating forensic cases of incineration and decomposition. Patients with panfacial third-degree burns (full thickness burns characterized by multicolored denatured layers, dry and insensitive to pain involving skin, subcutaneous tissues, adnexal structures and nerves and that usually require skin grafting) were examined within 72 hours after their accident. In addition, human cadavers stored in a mortuary at 5°C with 30 to 40 percent relative humidity and kept for a minimum of seven days were assessed for the condition of the palatine rugae. The authors took photographs of the palatine rugae by using a palatal mirror. The study results showed that among the subjects with third-degree panfacial burns, 93 percent of the palatine rugae were normal. The authors observed no changes in the color or surface anatomy of the palatine rugae in 77 percent of the human cadavers.

They concluded that the palatine rugae could be used as a reference landmark during forensic identification of an individual.

Ines Morais Caldas ,2007[21] stated that among the common methods used in the forensic sciences for confirming the identity of a person are fingerprinting, DNA analysis, and dental comparison.

Kamala R et al ,2011[48] in their comparison of rugae patterns in siblings, twins and with their parents revealed no similarity of rugae patterns. They suggested that there is no evidence of rugae features inheritance.

PR AND DENTISTRY

Buchtová et al, 2003[4] stated that physiologically the palatal rugae are involved in the oral swallowing and help to improve the relationship between food and the taste receptors in the dorsal surface of the tongue .

Thomas et al., 1987[12] stated PR also participated in speech and in the suction in children.

Palatine rugae in speech and palatal prostheses:

Snow,1889[49] described the significance of adequate but not excessive contour in the anterior palatal and premolar areas. Central and lateral lisping may develop when the contours of the prosthesis are incorrect. Patients whose speech is sensitive to a changed relationship of the tongue to a palatal prosthesis may require surface texture to orient the tongue.

Landa,1935[50] reported that rugae in dentures are ineffectual or sometimes detrimental to speech if they add unnecessary thickness to the anterior palatal region.

Moses ER Jr, Speech QJ,1940[51] stated that Palatography has been used to determine the optimum thickness and shape of the palatal surfaces. This approach was developed in a study of phonetics to determine the contact position of the tongue relative to the palate in the production of specific sounds essentially, application of these techniques ensured contact between the tongue and palate during articulation of these sounds. The "s" and "sh" phonemes have received particular attention.

Bloomer HH, JADA ,1943[52] stated that Palatography frequently has served as the basis for determining the shape of the anterior palatal vault most conducive to satisfactory sound articulation.

Pound E ,1951[53] stated that the palatine rugae and the IP often can serve as a cue [23,24]. Because the lack of texture on the palatal portion of a complete denture can impede proper articulation, one solution is to add palatine rugae. Unfortunately, the addition of rugae to a prosthesis is not a foolproof method of eliminating speech problems.

Silverman MM,1967[54] stated that the shape of the palatal vault is of particular interest to prosthodontists.

Chierici G, Lawson L,1973[55] stated that the significance of palatine rugae in relationship to speech has not been established. These characteristic soft-tissue ridges are present in all primates, and no experimental evidence exists to support their consideration as a speech organ.

Gitte et al,1999 [56] describe a method that palatal rugae are added to the palate maxillary complete dentures to improve the patterns of verbal expression and phonetics in some patients.

Palatine rugae in cleft palate patients:

Early diagnosis of submucosal cleft palate is important. In children too young to tolerate nasendoscopy and videofluoroscopy, the diagnosis depends on the patient's clinical history and intraoral examination findings.

Park et al., 1994[57], studied the pattern of palatal rugae in submucous cleft palates and isolated cleft palates & concluded that palatal rugae can be used as benchmarks when testing in pre-and postsurgical cleft palate surgery.

Kratzsch H and Opitz CJ,2000[58] investigated the relationship of palatine rugae to points(landmarks) and distances on the cleft palate during the period from birth to the time of early mixed dentition. The authors identified changes in the distances from the lateral palatine rugae points of the first and third rugae to the incisal point, the canine point and the tuberosity line. The results of their study indicated that a comparison of distances from the palatine rugae with distances between equivalent points revealed the changes that occurred in the anterior palate during various stages of orthodontic therapy and growth.

Ikemi *et al*., 2001 [59] stated that it is important to note the existence of abnormal patterns and shapes on palatal rugae, these anomalies are considered as a reflection of alterations

in the normal growth of the palate. It has been suggested that these abnormal patterns can be used as an additional feature or sign in the diagnosis of cleft palate in humans.

Landmark in orthodontic treatment:

Almeida et al,1955[24] studied to determine if the palatal rugae are stable during normal growth, and whether treatment with either headgear or functional appliances affects the position of the rugae. They concluded that the linear distances between medial points of the first rugae and the anteroposterior distances between the medial points of the second and third rugae did not show statistically significant changes in all groups. Significant changes were observed for the lateral points of the rugae, particularly in the headgear group. The medial rugae appear to be suitable anatomic points for the construction of stable reference planes for longitudinal cast analysis.

Peavy and Kendrick,1967[15] reported that the lateral ends of the rugae that terminated close to the teeth followed the movement of the teeth in the sagittal plane, but not in the transverse plane.

Reuer,1973[60] aimed to evaluate the stability of the palatal rugae area before and after orthodontic treatment, and to suggest whether it could be used in superimposition in order to analyze orthodontic treatment change. The most reliable points were found to be the lateral third rugae points, which could be used as reference points for cast superimposition.

Van der Linden FP etal,1978[12] Dental casts are three dimensional (3-D) records of malocclusion that have been used successfully during diagnosis and treatment planning for orthodontic patients. The palatine rugae are unique to each patient and are reasonably stable during the patient's growth thus, they may serve as suitable reference points from which the clinician can derive the reference planes necessary for longitudinal cast analysis. Positional changes of posterior teeth in the anteroposterior direction are relevant to the diagnosis and correction of sagittal occlusal abnormalities and arch length discrepancies.

Van der Linden FP ,1978[26] evaluated changes in the position of posterior teeth in relation to palatine rugae in 65 normally growing children (aged 6 to 16 years) and in six orthodontically treated patients. The maximum mean change in distance between the rugae in the anteroposterior plane was 0.41 mm. The authors noted larger movements at both the medial and lateral rugae points in the orthodontically treated patients.

Simmons JD, Moore RN, Erickson LC 1987[27] Palatine rugae can be used as internal dental-cast reference points for quantification of tooth migration in cases of orthodontic treatment.

Bailey et al,1988[61] studied to determine whether the positions of the palatal rugae were affected by orthodontic therapy, pre- and post-treatment maxillary dental casts of patients treated were evaluated. None of the changes observed in the transverse measures were statistically different between the two groups. The medial and lateral points of the third rugae appeared to be stable landmarks for the construction of anatomic reference points in longitudinal cast analysis.

English WR etal,1988[11] Thus, they may serve as suitable reference points from which the clinician can derive the reference planes necessary for longitudinal cast analysis. The palatine rugae are permanent and unique to each person and can establish identity through discrimination (via casts, tracings or digitized rugae patterns).

Hausser,1989[62] observed orthodontically treated patients and concluded that the lateral edges of the rugae moved forward about one half the distance of the migration of the adjacent teeth, while the medial rugae were not affected in a study of changes occurring in 15 patients who underwent extraction of four premolars.

Hoggan BR, Sadowsky C ,2001[63] investigated the use of the palatine rugae as reference points for measuring tooth movement in a manner comparable with cephalometric superimpositions. The authors evaluated the anteroposterior movement of the maxillary first molars and central incisors with the use of two cephalometric variables and six study model variables, and they combined the right and left sides of the palate. The results showed no statistical differences between the mean incisor and molar movement measured cephalometrically and the tooth movement measured relative to the medial and lateral end of the third palatine ruga. Thus, the authors concluded that palatine rugae could be used reliably to assess anteroposterior tooth movements.

Panagiotis Christo and Stavros Kiliaridi,2008[64] studied to assess the long-term stability of the palatal rugae in the vertical dimension, and relate them to possible maxillary incisor posteruptive movements, and validate them as references for the evaluation of longitudinal dental changes. Vertical changes were greater for the first rugae (closest to the incisors), less for the second, and even less for the third (farthest from the incisors). The adolescents showed greater vertical changes in rugae position than

the adults. There were no statistically signiicant differences in the anteroposterior changes between the groups. The maxillary central incisor and the first ruga had vertical displacements proportional to the increase of the subject's lower anterior facial height. The third ruga, the farthest from the incisors, can be used as a reliable reference to assess longitudinal dental changes mainly when growth changes are less prominent.

Shriram C Bansode et al,2009[10] analysed only some changes in the rugae pattern during orthodontic treatment by evaluating the preoperative and postoperative orthodontic casts of 60 patients. They also assessed that the morphology of palatal rugae remains stable throughout life and carefully assessed rugae pattern has definite role in forensic practice.

Janalt Damstra et al,2009 [65] did a study to investigate the stability of the medial aspects of the rugae in patients where rapid maxillary expansion (RME) was performed in addition to fixed appliance therapy and found that the addition of RME to fixed appliance therapy caused a change in transverse measurements between the medial aspects of the bilateral rugae. There was no change in antero-posterior measurements (APM). The transverse changes were more marked for the third, less for the second rugae, and the least for the first rugae. They concluded that the medial aspects of the third rugae cannot be considered as stable reference landmarks for dental cast analysis when RME is performed in addition to fixed appliance therapy.

Janga I; Motohiro Tanaka et al,2009[66] evaluated the stability of palatal rugae as landmarks for superimposition of dental casts and to establish a three-dimensional superimposition method of maxillary dental casts for analyzing orthodontic tooth movement. Dental casts were measured by means of laser surface scanning system, and

three-dimensional images were reconstructed, the results showed medial points of the third palatal rugae and the shape of the palatal vault were stable throughout the treatment.

Shukla D et al 2011[67] in their study to determine in their study done to establish the reliability of palatal rugae pattern in individual identification (following orthodontic treatment) have demonstrated that although some changes do occur in the rugae during orthodontic treatment, the morphology of palatal rugae remains stable throughout life. Hence carefully assessed rugae pattern may have a definite role in forensic identification.

Anukool H. et al,2011[68] also conducted a study to evaluate the changes in PR after orthodontic treatment and found that when pre and post transverse and anteroposterior changes were compared, no statistically significant difference was found ($P>0.05$). They proved that rugoscopy have the potential to identify an individual even after orthodontic treatment also.

M Kulkarni, Dr. P Gore,2013[69] in their study concluded that although some changes do occur in the rugae during orthodontic treatment, the morphology of palatal rugae remains stable throughout life and carefully assessed rugae pattern has definite role in forensic practice. They commented, it appears that the pattern of palatal rugae is unique to each individual and that it can therefore be used for establishing identity.

Variation of rugae pattern in different ethnic groups:

There seems to be a significant association between rugae forms and ethnicity.

Kashima k,1990[22] compared the palatine rugae and shape of the hard palate in Japanese and Indian children. They found the following: Japanese children had more primary rugae than did Indian children, but both groups had the same number of transverse palatine rugae. The two groups differed with regard to primary rugae shapes, the posterior boundary of the rugal zone, and the number and position of the secondary and fragmentary rugae. The palatal raphae of the Japanese children were wider than those of the Indian children. Both groups had many transverse palatine rugae on the left side of the palate. The posterior border of the rugal zone on the left side was shifted farther back than it was on the right side. There were no significant differences between the two sexes in either group.

Dohke and Osato(1994)[70], in a study on the Japanese population reported that numbers of rugae on the right side were fewer than on the left side taking into account both primary and secondary rugae.

Kapali S etal,1997[14] studied the palatal rugae pattern in Australian Aborigines and whites. They observed the number, length, shape, direction and unification of rugae. The authors concluded that the mean number of primary rugae in Australian Aborigines was higher than that in whites, although whites had more primary rugae that exceeded 10 mm in length. The most common shapes in both ethnic groups were wavy and curved forms, while straight and circular forms were least common**.**

Shetty SK etal,2005[23] compared the palatine rugae patterns in Indians with those in a Tibetan population. The results of their study showed that males had more rugae on the right side than on the left side in both populations, Indian males had more primary rugae on the left side than did females and vice versa for the Tibetan population,and Indian males had more curved rugae than did Tibetan males.

Rai et al,2007[71] showed straight type rugae were common in North Indian population. This study helps in identifying the North Indian population.

Paliwal A etal ,2010[72] compared the palatal rugae patterns in two different populations in India-Madhya Pradesh and Kerala. The results showed that the straight rugae pattern on the right side of palate in the males was found to be significantly predominant in Madhya Pradesh population, whereas wavy shape was predominant in Keralites; however rugae patterns on the right side of the palate in female subjects exhibited no significant difference.

Kallianpur S., Desai et al, 2011[73] showed that the numbe**r** of rugae in Indians were more on the right side than the left side and vice versa in Napalese population. In their study they also reported that the predominant shape of palatal rugae seen in both study groups were the wavy type followed by curved in Indians and straight in Napalese.

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Indira AP etal,2012 [38] in their study done on Banglore population found that the palatal rugae pattern in all 100 subjects were distinct and unique. None of the patterns were identical and also no bilateral symmetry was observed in any individual.

Bakkannavar et al,2012[74] did a study on Manipal population, India and noted that the Indian females had more number of rugae on the right side of the palate than the male

counterparts. Curved and straight shapes were predominant among the females whereas the wavy pattern was more common among the males.

Seenivasan Madhankumar etal,2013[75] in their study done on Chennai population found straight and curve forms were most prevalent rugae shapes in both the genders which is not comparable to our study.

Amit Byatnal et al,2014[76] studied the frequency distribution of different rugae shapes in five different states of India and showed that "wavy" type of rugae pattern was commonly found, followed by straight type in all other states except in Tamil Nadu where curved was second predominant.

STUDY DESIGN: CROSS SECTIONAL STUDY

This cross sectional study was carried out in the Department Of Orthodontics and Dentofacial Orthopaedics, Tamilnadu Government Dental College and Hospital, Chennai using previously existing records (maxillary dental casts) of the patients who reported for treatment to determine the relationship between palatal rugae pattern (fig.1) and different maxillary anteroposterior dysplasia(APD).

Armamentarium used

- The materials used in preparation of these already existing dental casts were
  - Alginate powder for recording of impressions,
  - Maxillary impression tray,
  - Mixing bowl and spatula,
  - Dental stone -orthokal and water for preparation of models.
- Le Cron instrument to remove air bubbles in the model(fig. 2)
- Equipments used for recording palatal rugae (fig. 2)
  - 0.3 mm graphite pencil
  - Ruler
  - Divider
  - SLR digital camera (Nikon D90)

Sample inclusion criteria

- Samples from subjects belonging to Indian origin were chosen randomly.
- Ninety samples (maxillary cast) in the age group of 15 to 25years who reported to the Department of Orthodontics, Tamil Nadu Dental College and Hospital, Chennai for treatment were selected.
- Selection of the samples was done based on cephalometric criteria.
- All the 90 samples had orthognathic mandible which wer selected on the following criteria-
    - ❖ Cephalometric criteria for orthognathic mandible-
        - ➢ SNB= 78 to 82^0
        - ➢ Pog to N perpendicular= -4 to 0 (females) and +2 to -2 (males)
- These 90 samples were divided into three groups based on cephalometric criteria for maxilla
    - ➢ Group 1 comprised of 30 casts with normal maxilla
    - ➢ Group 2 comprised of 30 casts with prognathic maxilla and
    - ➢ Group 3 comprised of 30 casts with retrognathic maxilla.

    - ❖ Cephalometric criteria for maxilla

Normal maxilla	Prognathic maxilla	Retrognathic maxilla
SNA= 80-84°	SNA > 84°	SNA < 80°
N$\underline{l}$ A= 0-1mm	N$\underline{l}$ A > 1mm	N$\underline{l}$ A < 0mm

Sample exclusion criteria

Photographs (Intra oral and extraoral) and the history of the patients were scrutinized using their case records to rule out the following-

- Finger sucking in childhood
- Congenital anomalies/malformations,
- Previous orthognathic surgery,
- Previous history of orthodontic treatment,
- Bony and soft tissue protuberances,
- Any active lesions in maxilla,
- Deformity or scars and
- Trauma of the palate

Maxillary dental casts chosen were prepared using the following procedure-

A. Preparing the alginate paste

B. Loading the impression tray

C. Taking the maxillary impressions

D. Preparation of the dental cast

METHODOLOGY

1. Identification and marking of palatal rugae

2. Cast analysis

1. Identification and marking of the palatal rugae

Before delineation, all air bubbles and nodules on the palatal aspect of dental casts, produced when the dental cast was poured, were removed with a Le Cron instrument. All

the maxillary dental casts were finished and polished without damaging the PR details. Palatal rugae were marked on the maxillary casts(fig.3) for all the 3 groups on both right and left sides of mid palatine raphae using a 0.3 mm graphite pencil under adequate light and magnification(fig.4,5,6) according to the classification given by Thomas and Kotze,1983[20] and Kapali et al,1997[14]. The samples were then photographed for each group by a standardized technique using a SLR digital camera (Nikon D90) with uniform settings and measurements were made.(fig.7,8,9)

2. Cast analysis

a) Number analysis- Right and left of the maxillary casts were named as right and left. Number of primary and secondary rugae were counted on both sides and entered into the tabulations for all respective groups.

b) Size analysis- According to size, the rugae were classified into primary rugae (≥5 mm), secondary rugae (3−5 mm), and fragmentary rugae (2-3 mm). Fragmentary rugae were not taken into account in the present study. A ruga's length was determined by measuring its greatest dimension regardless of its shape. A divider (fig.10) and measuring scale (fig.11) were used to measure the size of primary and secondary PR. All the marked rugae were named R1, R2, R3 in a sequential manner for the right side and in a similar way L1, L2, and L3 for the left side, from anterior to posterior of the hard palate. The values were then tabulated for each group samples in the same manner.

c) Shape analysis-The rugae were categorized according to shape (fig.12-A,B&C) as curved(CU) type (crescent shaped gently curving form), wavy (WA)type (curved rugae

with a slight curve at origin or termination), straight (ST) type (running directly from their origin to termination), and circular (CI) type (having a continuous ring). Based on unification, two rugae having different origins joining at their lateral portions were termed converging (CO), while two rugae with the same origin and then branching were considered diverging (DIV). Corresponding shapes were then entered in the table for both right and left side.

METHOD FOR STATISTICAL ANALYSIS

The data were entered by using Statistical Software SPSS (statistical package for the social sciences), version 16 and Microsoft Excel 2010 Software. The values obtained were statistically analyzed using KARL PEARSON Chi-square test to find the distribution of proportions among the samples and to find if any relationship existed between patterns of palatal rugae. One way Analysis of variance (ANOVA) with Tukey's Post –Hoc test was used to find out if any relationship existed between the sizes of palatal rugae. Analysis of the differences between each corresponding pattern among different groups was done by using the chi-square test and ANOVA test of significance at a confidence interval of 95%.

Figure 1:-Maxillary dental cast showing palatal rugae

Figure 2:- Armamentarium used for recording palatal rugae

Figure 3:-Marking of palatal rugae with 0.3mm pencil

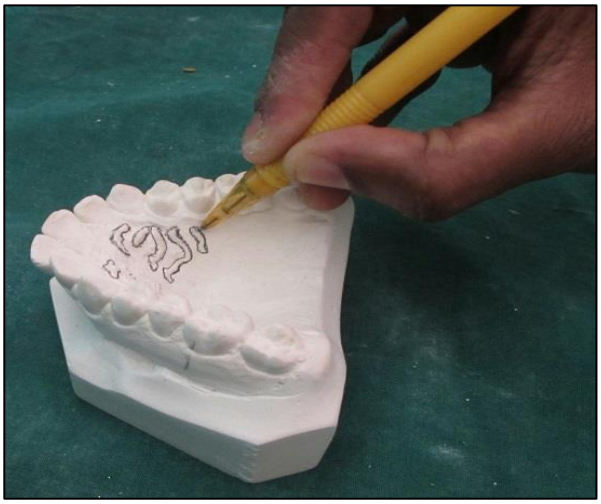

Figure 4:- Cast showing Rugae tracing in orthognathic maxilla

Figure 5:-Cast showing Rugae tracing in prognathic maxilla

Figure6:- Cast showing rugae tracing in retrognathic maxilla

Figure7:- Samples showing recorded palatal rugae for group 1 orthognathic maxilla

Figure 8:- Samples showing recorded palatal rugae for group 2 prognathic maxilla

Figure 9:- Samples showing recorded palatal rugae for group 3 retrognathic maxilla

Figure 10:- Length measurement of palatal rugae using divider

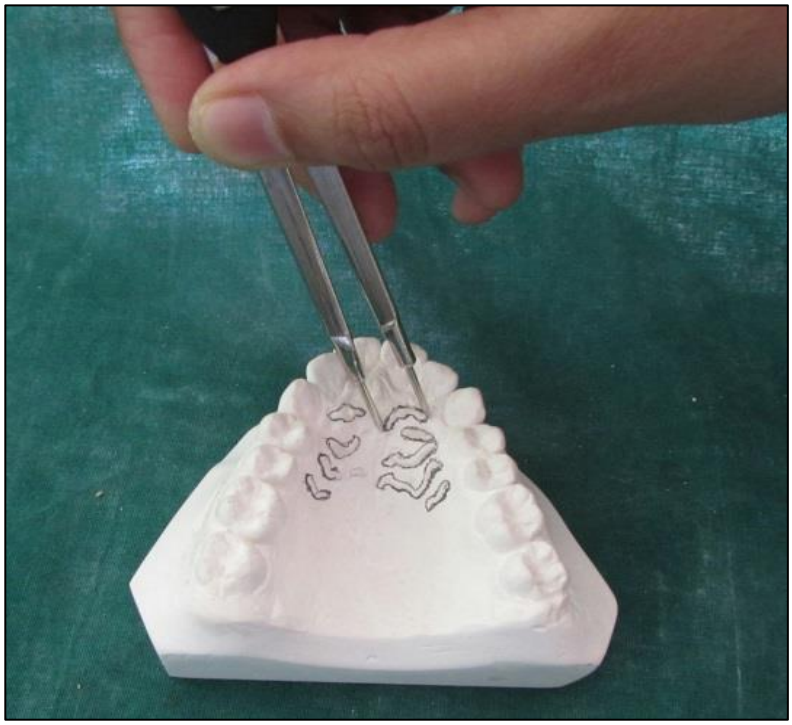

Figure 11:- Recording size using scale

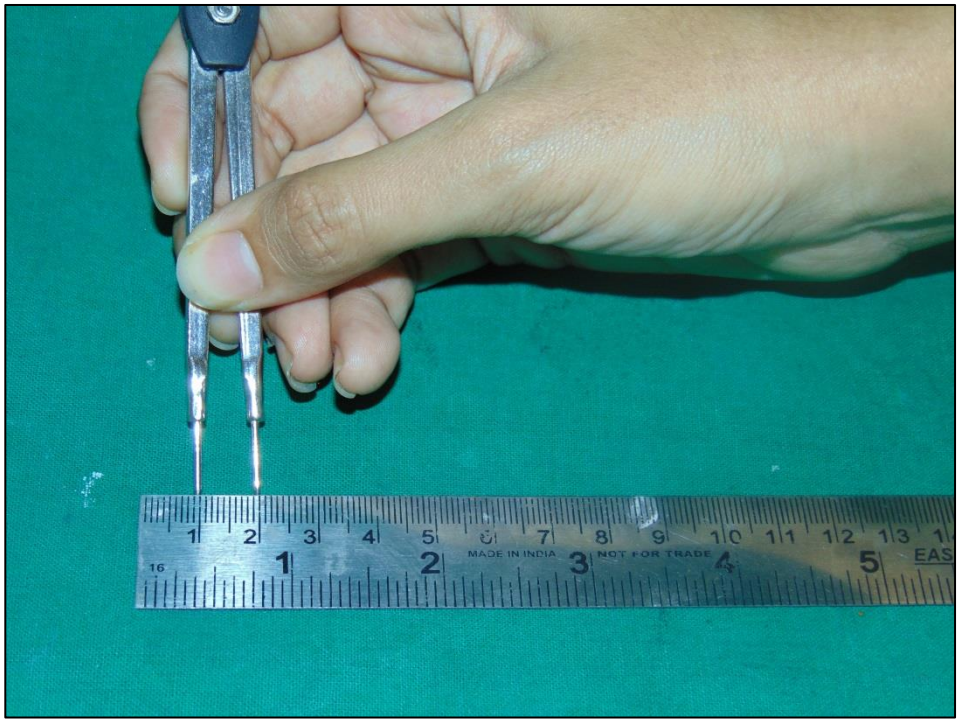

Figure 12:-A-classification of rugae shape:1- Straight, 2-curved,3-wavy, 4-unification(diverging)

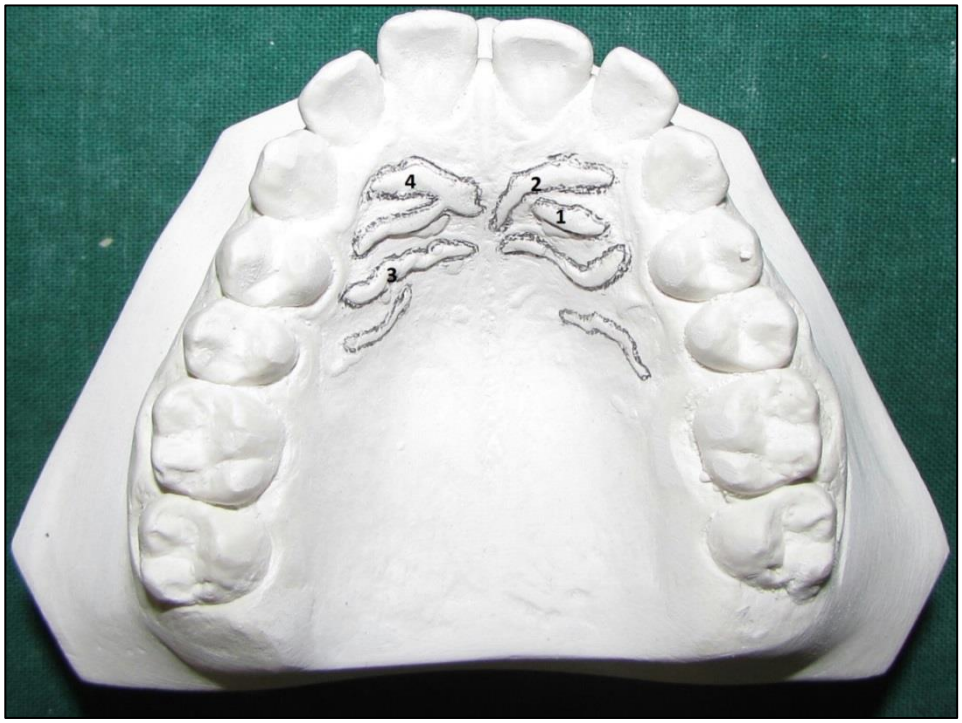

Figure 12:-B-classification of rugae shape: 1- circular

Figure 12:-C-classification of rugae shape: 1-diverging ; 2- converging

Table 1, shows distribution of the number of Rugae among Orthognathic, Prognathic and Retrognathic maxilla for the Left Side

S.NO.	ORTHOGNATHIC PROFILE	PROGNATHIC PROFILE	RETROGNATHIC PROFILE
1	4	3	4
2	3	4	4
3	3	3	4
4	4	3	4
5	6	4	3
6	5	4	3
7	3	4	3
8	4	2	4
9	3	4	3
10	3	3	3
11	3	4	3
12	3	4	4
13	3	3	4
14	4	4	4
15	3	4	2
16	3	4	4
17	5	5	3
18	3	4	4
19	5	4	5
20.	4	3	4
21	3	4	3
22	3	4	4
23	5	4	3
24	5	4	3
25	5	5	3
26	4	4	4
27	2	4	4
28	5	4	4
29	5	3	3
30	4	3	4

Table 2, shows distribution of the number of Rugae among Orthognathic, Prognathic and Retrognathic maxilla for the Right Side

S.NO.	ORTHOGNATHIC PROFILE	PROGNATHIC PROFILE	RETROGNATHIC PROFILE
1	4	3	4
2	3	4	4
3	3	3	4
4	4	3	4
5	6	4	3
6	5	4	3
7	3	4	3
8	4	2	4
9	3	4	3
10	3	3	3
11	3	4	3
12	3	4	4
13	3	3	4
14	4	4	4
15	3	4	2
16	3	4	4
17	5	5	3
18	3	4	4
19	5	4	5
20.	4	3	4
21	3	4	3
22	3	4	4
23	5	4	3
24	5	4	3
25	5	5	3
26	4	4	4
27	2	4	4
28	5	4	4
29	5	3	3
30	4	3	4

Table 3, shows distribution of the number of Rugae among Orthognathic, Prognathic and Retrognathic maxilla for the left Side and chi square test of significance.

			Left				Total
			3	4	5	6	
Groups	Orthognathic	Count	9	16	4	1	30
		% within Groups	30.0%	53.3%	13.3%	3.3%	100.0%
		% within Left	37.5%	32.0%	30.8%	33.3%	33.3%
	Prognathic	Count	10	14	5	1	30
		% within Groups	33.3%	46.7%	16.7%	3.3%	100.0%
		% within Left	41.7%	28.0%	38.5%	33.3%	33.3%
	Retrognathic	Count	5	20	4	1	30
		% within Groups	16.7%	66.7%	13.3%	3.3%	100.0%
		% within Left	20.8%	40.0%	30.8%	33.3%	33.3%
	Total	Count	24	50	13	3	90
		% within Groups	26.7%	55.6%	14.4%	3.3%	100.0%
		% within Left	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	11.127[a]	6	**.085**
Likelihood Ratio	12.765	6	.047
Linear-by-Linear Association	2.152	1	.142
N of Valid Cases	36		

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .28.

Table 4, shows distribution of the number of Rugae among Orthognathic, Prognathic and Retrognathic maxilla for the right Side and chi square test of significance.

Crosstab

			Right					Total
			2	3	4	5	6	
Groups	Orthognathic	Count	1	13	7	8	1	30
		% within Groups	3.3%	43.3%	23.3%	26.7%	3.3%	100.0%
		% within Right	33.3%	39.4%	16.7%	72.7%	100.0%	33.3%
	Prognathic	Count	1	8	19	2	0	30
		% within Groups	3.3%	26.7%	63.3%	6.7%	.0%	100.0%
		% within Right	33.3%	24.2%	45.2%	18.2%	.0%	33.3%
	Retrognathic	Count	1	12	16	1	0	30
		% within Groups	3.3%	40.0%	53.3%	3.3%	.0%	100.0%
		% within Right	33.3%	36.4%	38.1%	9.1%	.0%	33.3%
	Total	Count	3	33	42	11	1	90
		% within Groups	3.3%	36.7%	46.7%	12.2%	1.1%	100.0%
		% within Right	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	9.692[a]	8	**.287**
Likelihood Ratio	10.110	8	.257
Linear-by-Linear Association	1.346	1	.246
N of Valid Cases	36		

a. 13 cells (86.7%) have expected count less than 5. The minimum expected count is .28.

Table 5 depicts the comparison of the length of R1 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla on left side

S.No.	Orthognathic	Prognathic	Retrognathic
1	11.5	11	9
2	9	9	9
3	9	10	11
4	8.5	10	9
5	9	10	8.5
6	9	10	9
7	9	12	8.5
8	7	12	6.5
9	9	9	9
10	11	8	9
11	10	11	12.5
12	7.5	12	7
13	10	13	8
14	11	10.5	8
15	10	9	10
16	11	10	13
17	10	10	13
18	10	12	8
19	10	8	11
20	10	9	8
21	9	9	11
22	11	8	8.5
23	12	10	11
24	10	12	11
25	10	8	11
26	11	10	6
27	10	10	9
28	8	8	9
29	9	10	8
30	9	9	9.5

Table 6 depicts the comparison of the length of R1 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla on right side

S.No.	Orthognathic	Prognathic	Retrognathic
1	9.5	10	8
2	10	12	9
3	8	11	10
4	9	9	9
5	8	10	8
6	10	6	7.5
7	9	11.5	8
8	7	12	9
9	11	9	13
10	11	8	11
11	10	11	12
12	7.5	8	9
13	8	11	10
14	8.5	10	8
15	12	9	10
16	12	9	10
17	8	9	7
18	10	10	10
19	13	8.5	11
20	10	8	7
21	10	9	12
22	13	7	7
23	11	11	11
24	10	11	9
25	8	9	9
26	9	11	8
27	8	9	9
28	7.5	7.5	9
29	8	10	7
30	8	9	9

Table 7-Oneway anova test for R1(mm) on both right and left sides

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Rtside	Orthognathic	30	9.4667	1.65536	.30223	8.8485	10.0848	7.00	13.00
	Prognathic	30	9.5167	1.48256	.27068	8.9631	10.0703	6.00	12.00
	Retrognathic	30	9.2167	1.58486	.28935	8.6249	9.8085	7.00	13.00
	Total	90	9.4000	1.56363	.16482	9.0725	9.7275	6.00	13.00
Leftside	Orthognathic	30	9.6833	1.15582	.21102	9.2517	10.1149	7.00	12.00
	Prognathic	30	9.9833	1.40494	.25651	9.4587	10.5079	8.00	13.00
	Retrognathic	30	9.3667	1.76622	.32247	8.7071	10.0262	6.00	13.00
	Total	90	9.6778	1.46937	.15489	9.3700	9.9855	6.00	13.00

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Rtside	Between Groups	1.550	2	.775	.312	**.733**
	Within Groups	216.050	87	2.483		
	Total	217.600	89			
Leftside	Between Groups	5.706	2	2.853	1.331	**.270**
	Within Groups	186.450	87	2.143		
	Total	192.156	89			

Table 8-Post-Hoc test for R1(mm) on both right and left sides

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval	
						Lower Bound	Upper Bound
Rtside	Orthognathic	Prognathic	-.05000	.40689	**.992**	-1.0202	.9202
		Retrognathic	.25000	.40689	**.813**	-.7202	1.2202
	Prognathic	Orthognathic	.05000	.40689	**.992**	-.9202	1.0202
		Retrognathic	.30000	.40689	**.742**	-.6702	1.2702
	Retrognathic	Orthognathic	-.25000	.40689	**.813**	-1.2202	.7202
		Prognathic	-.30000	.40689	**.742**	-1.2702	.6702
Leftside	Orthognathic	Prognathic	-.30000	.37799	**.708**	-1.2013	.6013
		Retrognathic	.31667	.37799	**.681**	-.5846	1.2180
	Prognathic	Orthognathic	.30000	.37799	**.708**	-.6013	1.2013
		Retrognathic	.61667	.37799	**.238**	-.2846	1.5180
	Retrognathic	Orthognathic	-.31667	.37799	**.681**	-1.2180	.5846
		Prognathic	-.61667	.37799	**.238**	-1.5180	.2846

Table 9 depicts the comparison of the length of R2 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla for left side

S.No.	Orthognathic	Prognathic	Retrognathic
1	13	14	10
2	9	10.5	9.5
3	14	7	12
4	4	8	9
5	6	11	5.5
6	10	8	10
7	7	12	5.5
8	6	7	4.5
9	10	7	7
10	14	10	7
11	12	7	7
12	12	2	7
13	7	9	8.5
14	11	11.5	10
15	9	10	5
16	6	5	7
17	11	11	16
18	9	12	8
19	7	8	10
20	9	9	7
21	9	7	11.5
22	12	8	7
23	5	10	14
24	8	12	11
25	5	9	7.5
26	11	12	8
27	11	11	11.5
28	6	9	10
29	9	11	7.5
30	9	7.5	10

Table 10 depicts the comparison of the length of R2 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla for right side

S.No.	Orthognathic	Prognathic	Retrognathic
1	9.5	11	5
2	13	7	11
3	10	8	7
4	7.5	10	13
5	9.5	10	9
6	9	10	10
7	8	13.5	9
8	11	13	9
9	12	9.5	14
10	14	10	11
11	5	8	8.5
12	14	12	14
13	7.5	6	12
14	9	13	10
15	11	9	12
16	6	7.5	7
17	4.5	10	11
18	10	5	7
19	15	10	11
20	7	15	7
21	11	13	10
22	10	9	7
23	11	13	12
24	7	9	13
25	9	8	7
26	11	5	8.5
27	18	8	12
28	9	8.5	11
29	10	12.5	9
30	7	9	11

Table 11-Oneway anova test for R2(mm) on both right and left sides

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Rtside	Orthognathic	30	10.1833	2.97832	.54376	9.0712	11.2955	4.50	18.00
	Prognathic	30	9.9500	2.62728	.47967	8.9690	10.9310	5.00	15.00
	Retrognathic	30	9.9500	2.33545	.42639	9.0779	10.8221	5.00	14.00
	Total	90	10.0278	2.63230	.27747	9.4765	10.5791	4.50	18.00
Lftside	Orthognathic	30	9.0333	2.73525	.49939	8.0120	10.0547	4.00	14.00
	Prognathic	30	9.1167	2.56865	.46897	8.1575	10.0758	2.00	14.00
	Retrognathic	30	8.9500	2.66636	.48681	7.9544	9.9456	4.50	16.00
	Total	90	9.0333	2.62850	.27707	8.4828	9.5839	2.00	16.00

ANOVA

		Sum of Squares	df	Mean Square	F	**Sig.**
Rtside	Between Groups	1.089	2	.544	.077	**.926**
	Within Groups	615.592	87	7.076		
	Total	616.681	89			
Lftside	Between Groups	.417	2	.208	.029	**.971**
	Within Groups	614.483	87	7.063		
	Total	614.900	89			

Table 12-Post-Hoc test for R2(mm) on both right and left sides

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval	
						Lower Bound	Upper Bound
Rtside	Orthognathic	Prognathic	.23333	.68682	**.938**	-1.4044	1.8710
		Retrognathic	.23333	.68682	**.938**	-1.4044	1.8710
	Prognathic	Orthognathic	-.23333	.68682	**.938**	-1.8710	1.4044
		Retrognathic	.00000	.68682	**1.000**	-1.6377	1.6377
	Retrognathic	Orthognathic	-.23333	.68682	**.938**	-1.8710	1.4044
		Prognathic	.00000	.68682	**1.000**	-1.6377	1.6377
Lftside	Orthognathic	Prognathic	-.08333	.68620	**.992**	-1.7196	1.5529
		Retrognathic	.08333	.68620	**.992**	-1.5529	1.7196
	Prognathic	Orthognathic	.08333	.68620	**.992**	-1.5529	1.7196
		Retrognathic	.16667	.68620	**.968**	-1.4696	1.8029
	Retrognathic	Orthognathic	-.08333	.68620	**.992**	-1.7196	1.5529
		Prognathic	-.16667	.68620	**.968**	-1.8029	1.4696

Table 13 depicts the comparison of the length of R3 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla for left side

S.No.	Orthognathic	Prognathic	Retrognathic
1	13	13	13.5
2	10	6	15
3	6	12	13
4	12	9.5	10.5
5	13.5	14	12.5
6	10	17	7
7	12	13.5	8.5
8	9	11	8
9	18	10	12
10	13	11	13
11	12	15	9
12	8	14.5	9
13	15	8	7
14	13	8.5	11
15	12	12	11
16	12	12	10
17	13	5.5	13
18	12	13	10
19	14	8	8.5
20	10	12	8
21	11	8.5	5
22	11	12	11
23	10	10	9
24	10	7	12
25	11	13	13
26	13.5	16	14
27	7	11	10
28	7	13	8.5
29	10	7	12
30	8.5	11	10

Table 14 depicts the comparison of the length of R3 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla for right side

S.No.	Orthognathic	Prognathic	Retrognathic
1	14	14	10.5
2	10	11.5	11
3	6	10	12
4	17	15	8
5	13	10	13
6	13	14	8.5
7	11		10
8	12	12	16
9	9	14	17
10	10	14	9
11	13	16	11
12	13	15	11
13	13	10	10
14	16	6	
15	12	10	10
16	17	7	10
17	11	14	13
18	13	12	7
19	14	9	8
20	10	5	11
21	12	7	11
22	13	12	15
23	10	6	14
24	12	8	9.5
25	11	11	10
26		11	10
27	9	10	11
28	8.5	11	7
29	8.5	13.5	8

Table 15-Oneway anova test for R3 (mm) on both right and left sides

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Rtside	Orthognathic	29	11.5862	2.81916	.52350	10.5139	12.6586	5.00	17.00
	Prognathic	29	10.8966	3.02484	.56170	9.7460	12.0471	5.00	16.00
	Retrognathic	29	10.6897	2.50861	.46584	9.7354	11.6439	7.00	17.00
	Total	87	11.0575	2.78641	.29873	10.4636	11.6513	5.00	17.00
Lftside	Orthognathic	30	11.2833	2.54844	.46528	10.3317	12.2349	6.00	18.00
	Prognathic	30	11.1333	2.91823	.53279	10.0436	12.2230	5.50	17.00
	Retrognathic	30	10.3000	2.44808	.44696	9.3859	11.2141	5.00	15.00
	Total	90	10.9056	2.65200	.27955	10.3501	11.4610	5.00	18.00

ANOVA

		Sum of Squares	df	Mean Square	F	**Sig.**
Rtside	Between Groups	12.782	2	6.391	.820	**.444**
	Within Groups	654.931	84	7.797		
	Total	667.713	86			
Lftside	Between Groups	16.839	2	8.419	1.203	**.305**
	Within Groups	609.108	87	7.001		
	Total	625.947	89			

Table 16-Post hoc test for R3(mm) on both right and left sides

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval	
						Lower Bound	Upper Bound
Rtside	Orthognathic	Prognathic	.68966	.73329	**.616**	-1.0599	2.4392
		Retrognathic	.89655	.73329	**.443**	-.8530	2.6461
	Prognathic	Orthognathic	-.68966	.73329	**.616**	-2.4392	1.0599
		Retrognathic	.20690	.73329	**.957**	-1.5427	1.9565
	Retrognathic	Orthognathic	-.89655	.73329	**.443**	-2.6461	.8530
		Prognathic	-.20690	.73329	**.957**	-1.9565	1.5427
Lftside	Orthognathic	Prognathic	.15000	.68319	**.974**	-1.4791	1.7791
		Retrognathic	.98333	.68319	**.325**	-.6457	2.6124
	Prognathic	Orthognathic	-.15000	.68319	**.974**	-1.7791	1.4791
		Retrognathic	.83333	.68319	**.445**	-.7957	2.4624
	Retrognathic	Orthognathic	-.98333	.68319	**.325**	-2.6124	.6457
		Prognathic	-.83333	.68319	**.445**	-2.4624	.7957

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Table 17 depicts the comparison of the length of R4 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla on left side

S.No.	Orthognathic	Prognathic	Retrognathic
1	11.5		13.5
2		7	14
3			14
4	12		9.5
5	5	15	
6	8	12	
7		18	
8	14		8
9		7	
10			
11		7	5
12	11	12	
13	10	16	11
14		17	8
15			6
16	14	8	14
17	8	10	
18	14	7	13
19	9		
20	11	16	10
21		10	11
22			
23	11	7	17
24	13		11
25		8	6
26	11	7	
27		14	13
28	8	14.5	10

Table 18 depicts the comparison of the length of R4 (mm) between the Orthognathic, Prognathic and Retrognathic for right side

S.No.	Orthognathic	Prognathic	Retrognathic
1	11.5		13.5
2		7	14
3			14
4	12		9.5
5	5	15	
6	8	12	
7		18	
8	14		8
9		7	
10			
11		7	5
12	11	12	
13	10	16	11
14		17	8
15			6
16	14	8	14
17	8	10	
18	14	7	13
19	9		
20	11	16	10
21		10	11
22			
23	11	7	17
24	13		11
25		8	6
26	11	7	
27		14	13
28	8	14.5	10

Table 19-Oneway anova for R4 (mm) on both right and left sides

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Rtside	Orthognathic	16	9.8438	2.47466	.61867	8.5251	11.1624	5.00	14.00
	Prognathic	21	10.7381	3.75373	.81913	9.0294	12.4468	5.00	18.00
	Retrognathic	17	10.2353	3.24576	.78721	8.5665	11.9041	6.00	17.00
	Total	54	10.3148	3.22036	.43824	9.4358	11.1938	5.00	18.00
Lftside	Orthognathic	21	11.9286	2.44073	.53261	10.8176	13.0396	6.00	15.50
	Prognathic	20	10.0500	3.03445	.67852	8.6298	11.4702	5.00	16.00
	Retrognathic	25	10.6200	3.18944	.63789	9.3035	11.9365	5.00	16.00
	Total	66	10.8636	2.97883	.36667	10.1313	11.5959	5.00	16.00

ANOVA

		Sum of Squares	df	Mean Square	F	**Sig.**
Rtside	Between Groups	7.420	2	3.710	.349	**.707**
	Within Groups	542.228	51	10.632		
	Total	549.648	53			
Lftside	Between Groups	38.540	2	19.270	2.256	**.113**
	Within Groups	538.233	63	8.543		
	Total	576.773	65			

Table 20-Post-Hoc test for R4(mm) on both right and left sides

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval	
						Lower Bound	Upper Bound
Rtside	Orthognathic	Prognathic	-.89435	1.08202	**.688**	-3.5063	1.7176
		Retrognathic	-.39154	1.13574	**.937**	-3.1332	2.3501
	Prognathic	Orthognathic	.89435	1.08202	**.688**	-1.7176	3.5063
		Retrognathic	.50280	1.06381	**.884**	-2.0652	3.0708
	Retrognathic	Orthognathic	.39154	1.13574	**.937**	-2.3501	3.1332
		Prognathic	-.50280	1.06381	**.884**	-3.0708	2.0652
Lftside	Orthognathic	Prognathic	1.87857	.91323	**.107**	-.3135	4.0706
		Retrognathic	1.30857	.86520	**.292**	-.7682	3.3853
	Prognathic	Orthognathic	-1.87857	.91323	**.107**	-4.0706	.3135
		Retrognathic	-.57000	.87687	**.793**	-2.6748	1.5348
	Retrognathic	Orthognathic	-1.30857	.86520	**.292**	-3.3853	.7682
		Prognathic	.57000	.87687	**.793**	-1.5348	2.6748

Table 21 depicts the comparison of the length of R5 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla for left side

S.No.	Orthognathic	Prognathic	Retrognathic
1	7.5	11	10
2	11	10	6
3	13	10	12
4	9	7	9
5	13	8	15
6	10	10	-

Table 22 depicts the comparison of the length of R5 (mm) between the Orthognathic, Prognathic and Retrognathic maxilla for right side

S.No.	Orthognathic	Prognathic	Retrognathic
1	11.5	18	11
2	8	6	
3	8	12	
4	10	7	
5	11		
6	12		
7	7		
8	9.5		
9	9.5		

Table 23-Oneway anova test for R5 (mm) on both right and left sides

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Rtside	Orthognathic	9	9.6111	1.70986	.56995	8.2968	10.9254	7.00	12.00
	Prognathic	4	10.7500	5.50000	2.75000	1.9983	19.5017	6.00	18.00
	Retrognathic	1	11.0000	.	.	.	.	11.00	11.00
	Total	14	10.0357	3.02213	.80770	8.2908	11.7806	6.00	18.00
Lftside	Orthognathic	6	10.5833	2.20038	.89830	8.2742	12.8925	7.50	13.00
	Prognathic	6	9.3333	1.50555	.61464	7.7534	10.9133	7.00	11.00
	Retrognathic	5	10.4000	3.36155	1.50333	6.2261	14.5739	6.00	15.00
	Total	17	10.0882	2.31999	.56268	8.8954	11.2811	6.00	15.00

ANOVA

		Sum of Squares	df	Mean Square	F	**Sig.**
Rtside	Between Groups	4.593	2	2.297	.221	**.805**
	Within Groups	114.139	11	10.376		
	Total	118.732	13			
Lftside	Between Groups	5.376	2	2.688	.466	**.637**
	Within Groups	80.742	14	5.767		
	Total	86.118	16			

Table 24-Post-Hoc test for R5(mm) on both right and left sides

Warnings

Post hoc tests were not performed for Right side because at least one group has fewer than two cases.

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval	
						Lower Bound	Upper Bound
Lftside	Orthognathic	Prognathic	1.25000	1.38651	**.648**	-2.3789	4.8789
		Retrognathic	.18333	1.45419	**.991**	-3.6227	3.9894
	Prognathic	Orthognathic	-1.25000	1.38651	**.648**	-4.8789	2.3789
		Retrognathic	-1.06667	1.45419	**.748**	-4.8727	2.7394
	Retrognathic	Orthognathic	-.18333	1.45419	**.991**	-3.9894	3.6227
		Prognathic	1.06667	1.45419	**.748**	-2.7394	4.8727

Table 25 depicts the comparison of the shape of R1 between the Orthognathic, Prognathic and Retrognathic maxilla for left side

Pattern	GROUPS		
	Orthognathic	**Prognathic**	**Retrognathic**
WA	6	6	6
CU	8	7	11
DIV	7	5	6
ST	5	4	2
CO	2	7	2
CI	2	1	3

Table 26 -Chi-Square Test for R1 pattern on left side

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	8.152[a]	10	**.614**
Likelihood Ratio	7.933	10	.635
Linear-by-Linear Association	.065	1	.799
N of Valid Cases	90		

Table 27 depicts the comparison of the shape of R1 between the Orthognathic, Prognathic and Retrognathi maxilla for right side

Pattern	GROUPS		
	Orthognathic	**Prognathic**	**Retrognathic**
WA	3	4	5
CU	9	5	7
DIV	8	6	9
ST	8	9	8
CO	2	4	1
CI	0	2	0

Table 28 -Chi-Square Test for R1 pattern on right side

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	8.332[a]	10	**.596**
Likelihood Ratio	8.764	10	**.555**
Linear-by-Linear Association	.170	1	**.681**
N of Valid Cases	90		

Table 29 depicts the comparison of the shape of R2 between the Orthognathic, Prognathic and Retrognathic maxilla for left side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	11	9	14
CU	10	8	7
DIV	2	6	2
ST	7	6	6
CO	0	1	1

Table 30 -Chi-Square Test for R2 pattern on left side

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.983[a]	10	**.534**
Likelihood Ratio	9.128	10	.520
Linear-by-Linear Association	.040	1	.842
N of Valid Cases	90		

Table 31 depicts the comparison of the shape of R2 between the Orthognathic, Prognathic and Retrognathic maxilla for the right side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	16	13	13
CU	3	6	11
DIV	2	5	2
ST	8	6	4
CO	1	0	0

Table 32 -Chi-Square Test for R2 pattern on the right side

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.662[a]	8	**.222**
Likelihood Ratio	10.802	8	.213
Linear-by-Linear Association	.721	1	.396
N of Valid Cases	90		

Table 33 depicts the comparison of the shape of R3 between the Orthognathic, Prognathic and Retrognathic maxilla for the left side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	16	19	20
CU	8	7	5
DIV	5	2	2
ST	1	2	2
CO	0	0	1

Table 34 -Chi-Square Tests for R3 pattern on the left side

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.573[a]	8	**.695**
Likelihood Ratio	5.704	8	.680
Linear-by-Linear Association	.073	1	.787
N of Valid Cases	90		

Table 35 depicts the comparison of the shape of R3 between the Orthognathic, Prognathic and Retrognathic maxilla for the right side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	15	19	14
CU	8	6	11
DIV	2	0	1
ST	3	4	3
CO	1	0	0

Table 36 -Chi-Square Test for R3 pattern on the right side

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	6.595[a]	8	**.581**
Likelihood Ratio	7.532	8	.480
Linear-by-Linear Association	.141	1	.707
N of Valid Cases	87		

Table 37 depicts the comparison of the shape of R4 between the Orthognathic, Prognathic and Retrognathic maxilla for the left side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	12	12	14
CU	5	6	6
DIV	0	0	1
ST	2	2	2
CO	1	0	0

Table 38 -Chi-Square Test for R4 pattern on the left side

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	4.021[a]	8	**.855**
Likelihood Ratio	4.440	8	.815
Linear-by-Linear Association	.196	1	.658
N of Valid Cases	63		

Table 39 depicts the comparison of the shape of R4 between the Orthognathic, Prognathic and Retrognathic maxilla for the right side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	10	12	11
CU	2	4	2
DIV	0	0	1
ST	3	3	2
CO	1	0	1

Table 40 -Chi-Square Test for R4 pattern on the right side

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	4.113[a]	8	**.847**
Likelihood Ratio	4.939	8	.764
Linear-by-Linear Association	.062	1	.804
N of Valid Cases	52		

Table 41 depicts the comparison of the shape of R5 between the Orthognathic, Prognathic and Retrognathic maxilla for the left side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	5	3	2
CU	0	1	0
ST	0	2	1

Table 42 -Chi-Square Test for R5 pattern on the left side

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.967[a]	4	**.411**
Likelihood Ratio	5.294	4	.258
Linear-by-Linear Association	1.585	1	.208
N of Valid Cases	14		

Table 43 depicts the comparison of the shape of R5 between the Orthognathic, Prognathic and Retrognathic maxilla for the right side

Pattern	GROUPS		
	Orthognathic	Prognathic	Retrognathic
WA	5	1	1
CU	2	0	0
ST	2	1	0

Table 44 -Chi-Square Test for R5 pattern on the right side

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.778[a]	4	**.777**
Likelihood Ratio	2.348	4	.672
Linear-by-Linear Association	.055	1	.814
N of Valid Cases	12		

Chart 1 shows the distribution of participants based on the number of rugae present in the Orthognathic, Prognathic and Retrognathic groups respectively for the left side

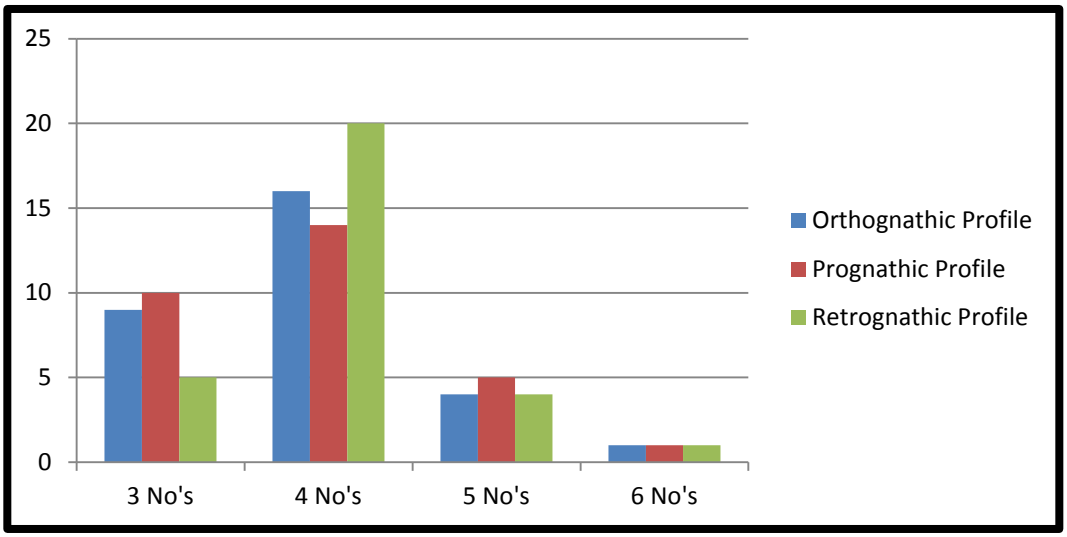


Chart 2 shows the distribution of participants based on the number of rugae present in the Orthognathic, Prognathic and Retrognathic groups respectively for the right Side

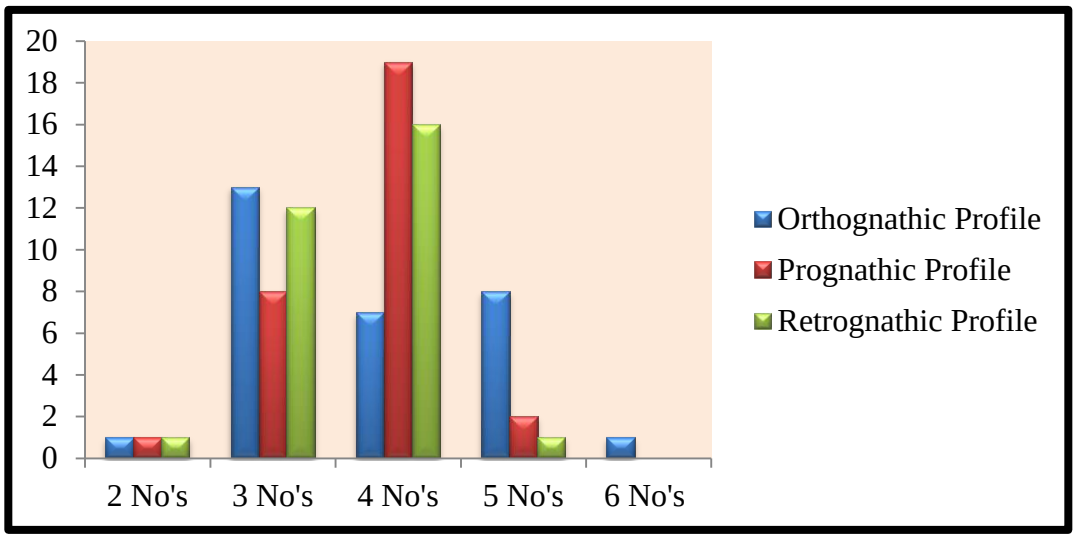


Chart 3 shows the mean of R1 in mm for both right & left sides

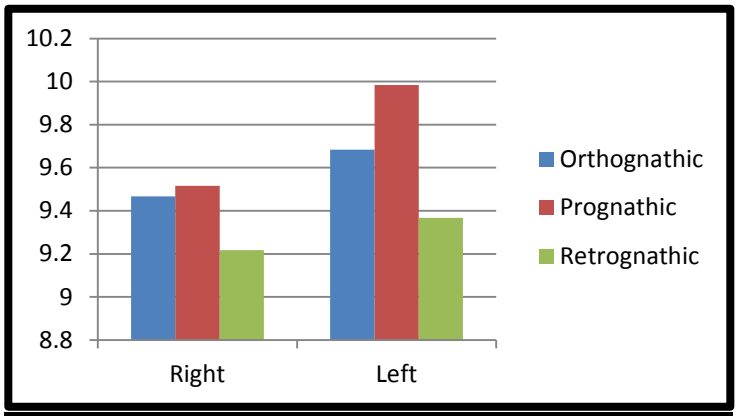


Chart 4 shows the mean of R2 in mm for both right and left sides

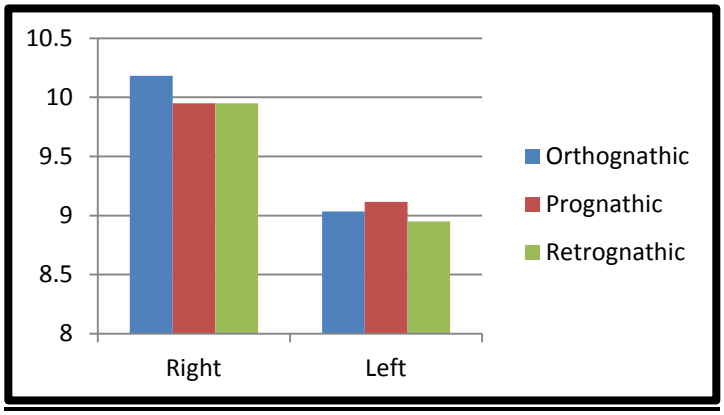


Chart 5 shows the mean of R3 in mm for both right and left sides

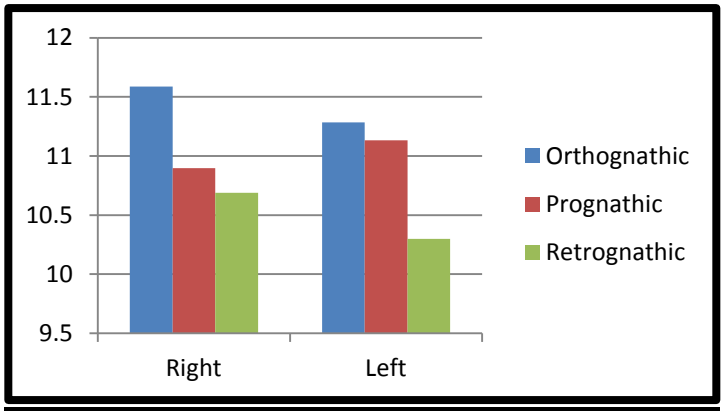


Chart 6 shows the mean of R4 in mm for both right and left sides

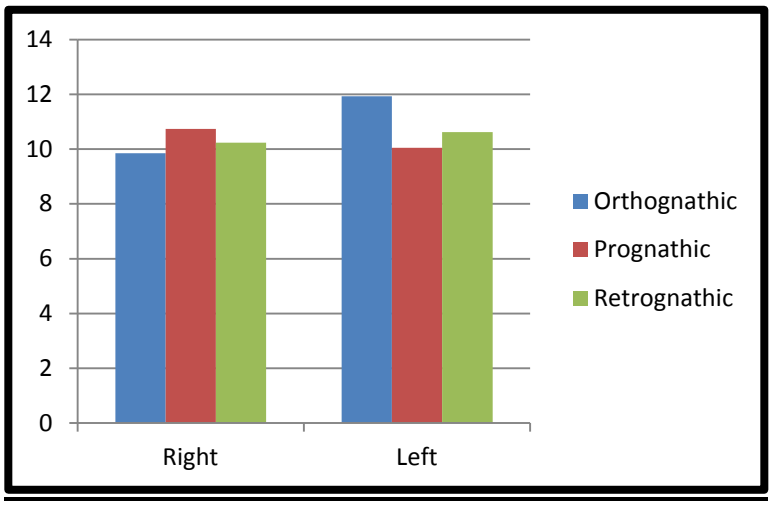


Chart 7 shows the mean of R5 in mm for both right and left sides

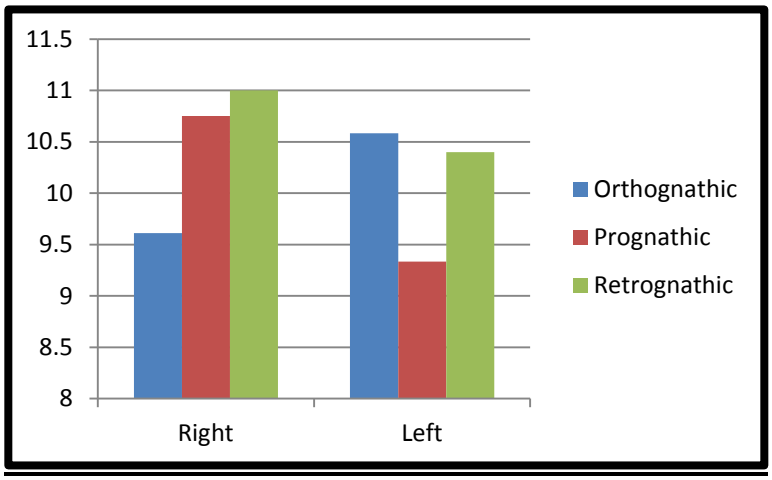


Chart 8-. Distribution of participants based on the shape of R1 rugae present in the Orthognathic, Prognathic and Retrognathic groups respectively for the left side

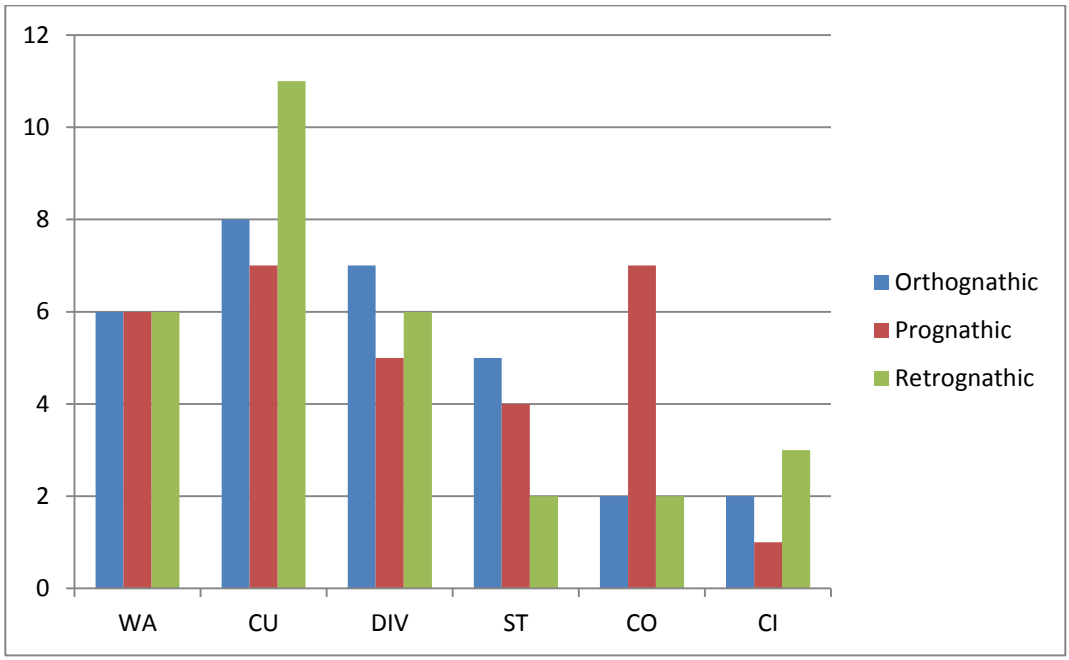


Chart 9-Distribution of R1 pattern for right side

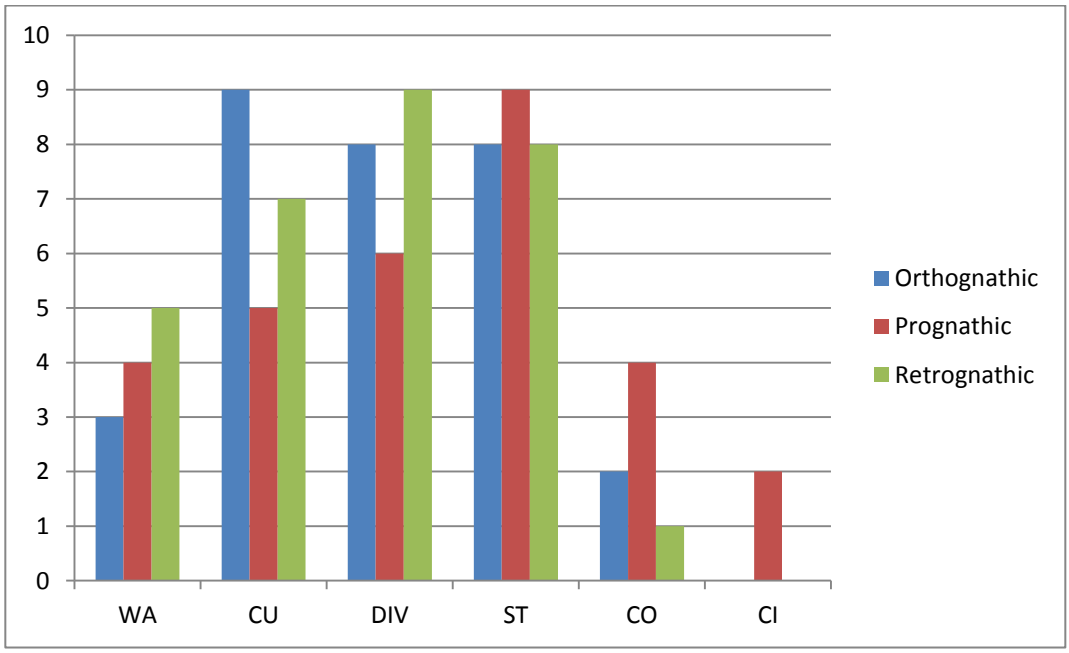


Chart 10- Distribution of participants based on the shape of R2 rugae present in the Orthognathic, Prognathic and Retrognathic groups respectively for the left side

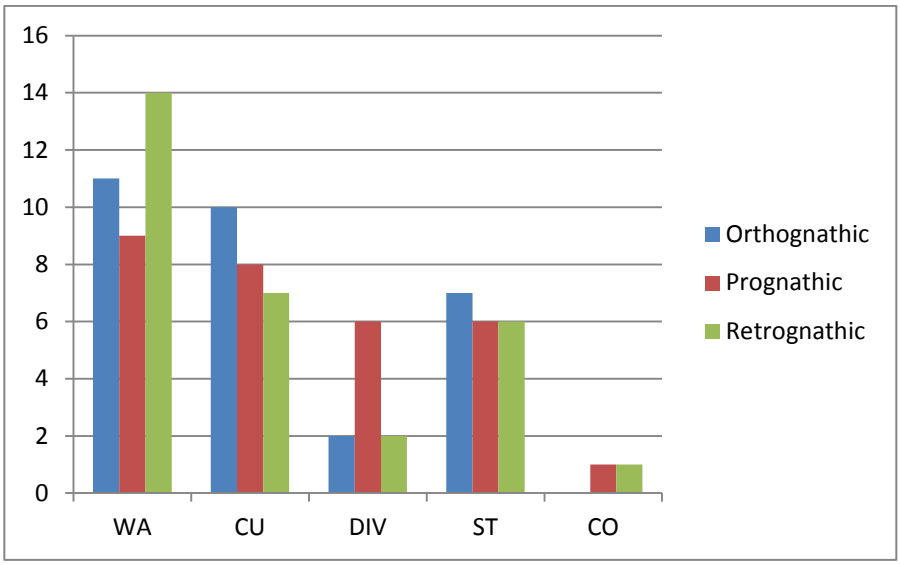


Chart 11-Distribution of R2 pattern for the right side –

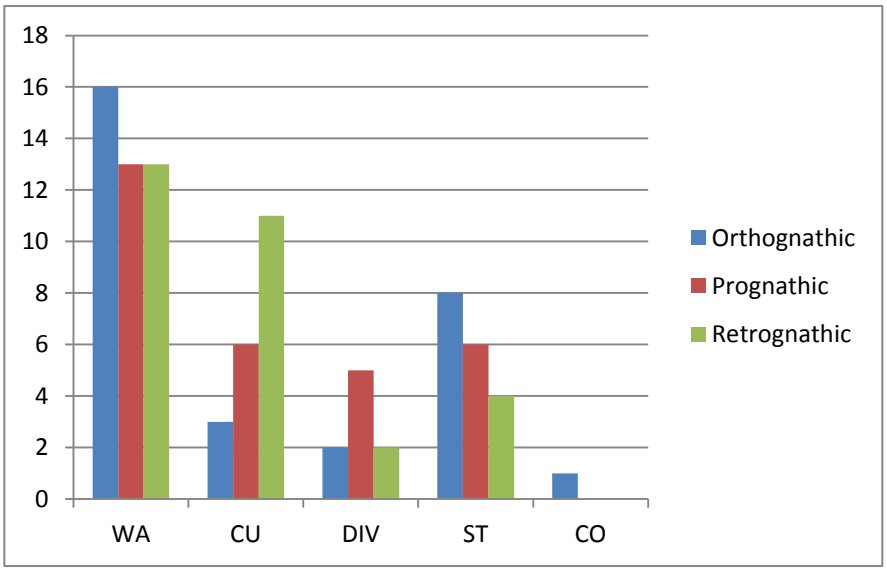


Chart 12- Distribution of R3 pattern for the left side –

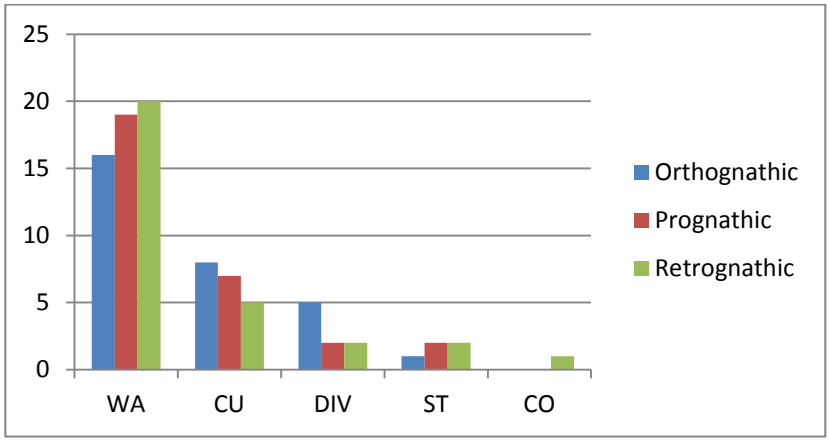


***Chart 13*- Distribution of R3 pattern for the right side –**

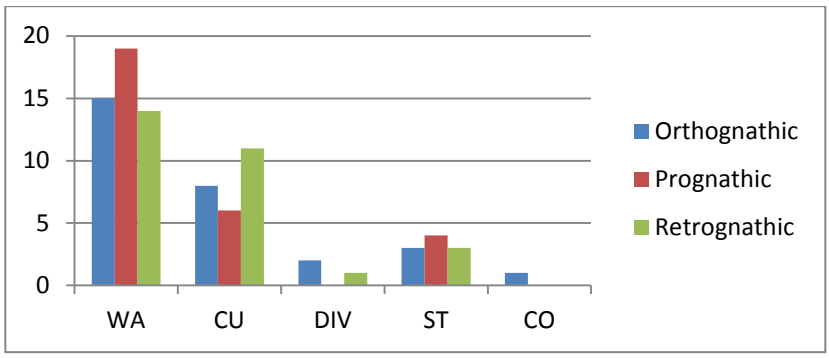


***Chart 14*- Distribution of R4 pattern for the left side –**

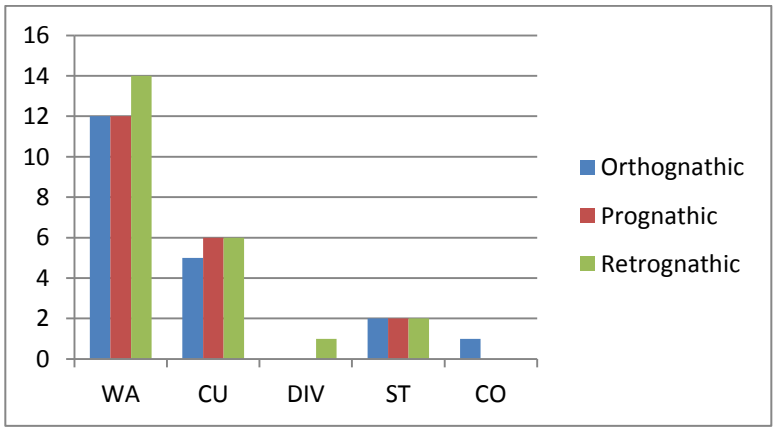


***Chart 15*- Distribution of R4 pattern for the right side –**

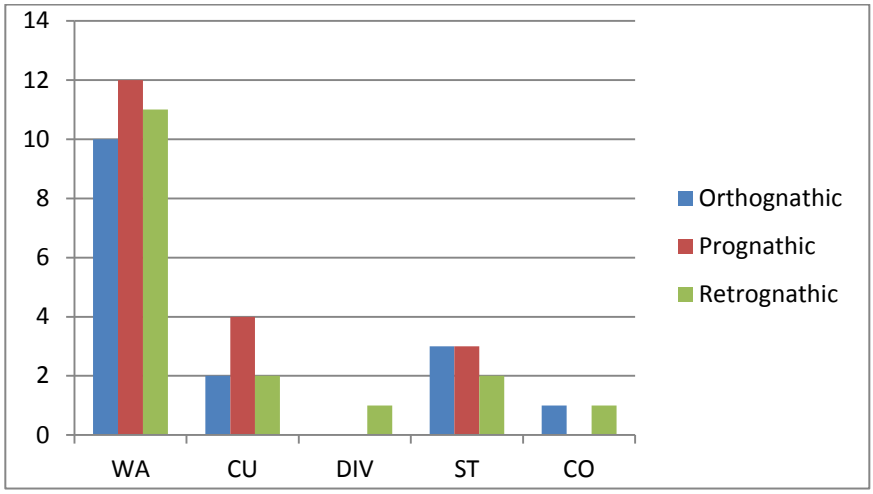


Chart 16 **-Distribution of R5 pattern for the left side –**

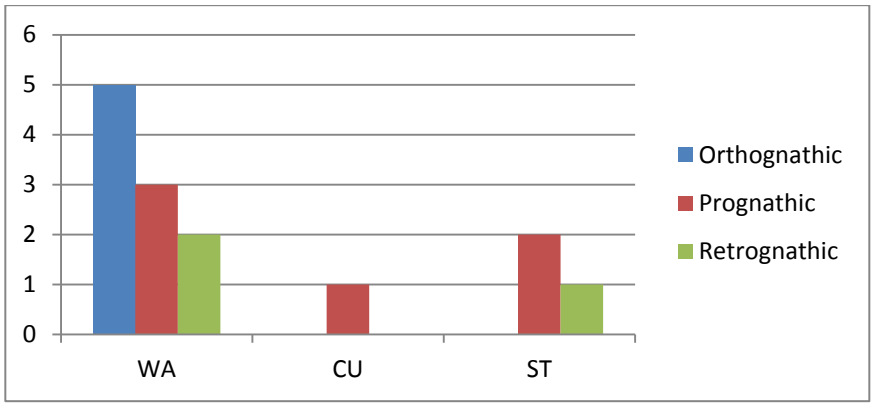
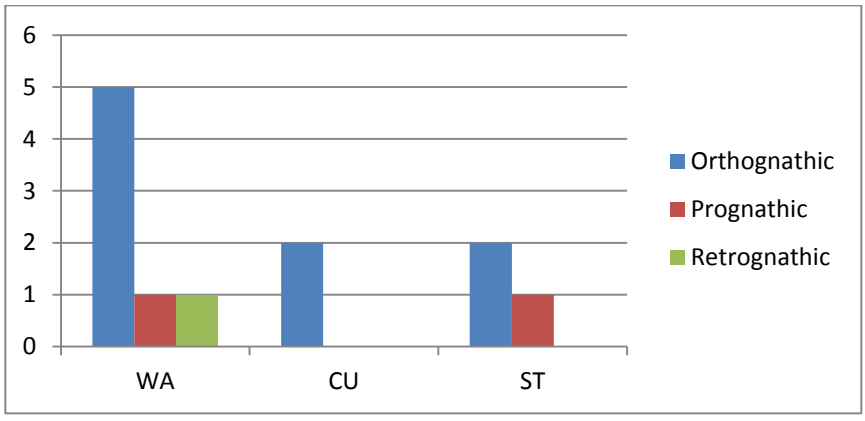


Chart 17**- Distribution of R5 pattern for the right side –**



RESULTS

The data was entered by using Statistical Software SPSS (statistical package for the social sciences), version 16 and Microsoft Excel 2007 Software. The values obtained were statistically analyzed using KARL PEARSON Chi-square test to find the distribution of proportions among the samples and to find if any relationship existed between the patterns of palatal rugae. One way Analysis of variance (ANOVA) with Tukey's Post–Hoc test was used to find out if any relationship existed between the sizes of palatal rugae. Analysis of the differences between each corresponding pattern among different groups was done by using the chi-square test and one way ANOVA test of significance at a confidence interval of 95%.

The following parameters were analyzed:

1. Comparison 1: overall comparison between 3 groups (orthognathic vs prognathic vs retrognathic) for the number of rugae using Pearsons chi square test separately for right side and left side.
2. Comparison 2: overall comparison between 3 groups (orthognathic vs prognathic vs retrognathic) for the size of rugae using one way Anova test separately for right side and left side.
3. Comparison 3: overall comparison between 3 groups (orthognathic vs prognathic vs retrognathic) for the pattern of rugae using Pearsons chi square test separately for right side and left side.

NUMBER OF RUGAE

The total number of rugae in all the 3 groups were tabulated for both left(table 1) and right side(table 2) and analyzed using chi-square test of significance which is represented by table 3 and fig.1 for the left side and table 4 and fig.2 for the right side respectively.

After interpretation of overall rugae number for 90 samples, it was found that rugae number varied in between 3-6 on left(table 3) and 2-6(table 4) on right side. Analyzing the number of rugae in all the 3 groups, it was found that the occurrence of 4 rugae was maximum with 55.6% of occurrence on the left side (table 3) and 46.7% on the right side (table 4). This was followed by 3 numbers (26.7%), 5 numbers(14.4%), and 6 numbers(3.3%) in descending order of occurrence on the left side(table 3), while the right side showed different order of occurrence as follows- 3 numbers(36.7%), 5 numbers(12.2%) , 2 numbers(3.3) and 6 numbers(1.1%)(table 4).

With P value of 0.806, there was no statistically significant difference found in the number of rugae among 3 groups (orthognathic vs prognathic vs retrognathic) on the left side as shown in table 3. On the right side, group with prognathic maxilla and retrognathic maxilla had shown high propensity for 4 rugae with 63.3% and 53.3% of the total sample respectively when compared to orthognathic maxilla which showed this propensity in only 23.3% of the total samples. Orthognathic maxilla had shown high propensity for 5 rugae in 26.7% of the total sample when compared to prognathic (6.7%) and retrognathic maxilla (3.3%). These differences between 3 groups were found to be statistically significant with P value of 0.034. (table 4). This was also appreciated in the fig.2.

SIZE OF RUGAE

The values for the length of all rugae in the three groups were tabulated for both left and right side and then analyzed using One way Anova and Post-Hoc test.

The comparison of the length of R1 (mm) among the 3 groups for both left and right side are shown in Table 5 and 6 respectively. One way Anova and Post-hoc test for both the sides are shown in table 7 and 8 respectively. On both the sides R1 followed the same pattern for their mean of the length which was as follows-prognathic maxilla> orthognathic maxilla> retrognathic maxilla. On the left side, the values for their mean were 9.983mm, 9.683 mm and 9.366mm respectively. On the right side it was 9.52mm, 9.47mm, and 9.22mm respectively. On both left and right sides, this difference was statistically insignificant as shown by a P value = 0.270 and 0.733 respectively. Fig.3 shows the diagrammatic representation of the R1 for both the sides.

The comparison of the length of R2 (mm) among the 3 groups for both left and right side are shown in Table 9 and 10 respectively. One way Anova and Post-hoc test for both the sides are shown in table 11 and 12 respectively. It was found that R2 on right side were larger in orthognathic maxilla (10.18 mm) followed by prognathic maxilla(9.95mm) and retrognathic(8.95mm) and this difference was found to be statistically insignificant as shown by a P value = 0.926. R2 on the left side were larger in prognathic maxilla (9.11 mm) followed by orthognathic maxilla (9.03mm) & retrognathic (8.95mm) and this difference was also statistically insignificant as shown by a P value = 0.971. Fig.4 shows the diagrammatic representation of the R2 for both the sides.

The comparison of the length of R3 (mm) among the 3 groups for both left and right side are shown in Table 13 and 14 respectively. One way Anova and Post-hoc test for both the sides are shown in table 15 and 16 respectively. It was found that R3 on the left side were larger in orthognathic maxilla (11.28mm) followed by prognathic maxilla (11.13 mm) & retrognathic (10.30mm) and this difference was statistically insignificant as shown by a P value = 0.305. R3 on the right side were larger in orthognathic maxilla (11.59mm) followed by prognathic maxilla (10.90 mm) & retrognathic (10.69mm) , this difference was statistically insignificant as shown by a P value = 0.444. Fig.5 shows the diagrammatic representation of the R3 for both the sides.

The comparison of the length of R4 (mm) among the 3 groups for both left and right side are shown in Table 17 and 18 respectively. One way Anova and Post-hoc test for both the sides are shown in table 19 and 20 respectively. It was found that R4 on the left side were larger in orthognathic maxilla (11.92 mm) followed by retrognathic maxilla (10.62 mm) & prognathic (10.05 mm) , this difference was statistically insignificant as shown by a P value = 0.113. R4 on right side were larger in prognathic maxilla (10.73mm) followed by retrognathic maxilla (10.23 mm) & orthognathic (9.84mm) , this difference was statistically insignificant as shown by a P value = 0.707. Fig.6 shows the diagrammatic representation of the R4 for both the sides.

The comparison of the length of R5 (mm) among the 3 groups for both left and right side are shown in Table 21 and 22 respectively. One way Anova and Post-hoc test for both the sides are shown in table 23 and 24 respectively. It was found that R5 on left side were larger in orthognathic maxilla (10.58 mm) followed by retrognathic maxilla

(10.4 mm) & prognathic (9.33 mm) , this difference was statistically insignificant as given by a P value = 0.637. R5 on right side were larger in retrognathic maxilla (11.00 mm) followed by prognathic maxilla (10.75mm) & orthognathic (9.61 mm) , this difference was statistically insignificant as given by a P value = 0.805. Fig.7 shows the diagrammatic representation of the R5 for both the sides.

SHAPE OF RUGAE

All the rugae shapes were tabulated for their corresponding groups in both left and right sides and then analyzed for statistical significance using chi-square test.

The frequency distribution of different shapes of R1 in all the 3 groups for both left and right side are shown in table 25 and 26 respectively. Chi-square results are shown in table 27 and 28 for the left and right side respectively. Fig. 8 and 9 shows the diagrammatic representation of the same respectively. Following pattern was found for R1 on the left side–in orthognathic maxilla, CU shape was more common followed by DIV>WA>ST>CO=CI shapes. In prognathic it was in CU=CO>WA>DIV>ST>CI order & in retrognathic it was found to be CU>DIV=WA>CI>ST=CO and this difference in pattern was statistically insignificant shown by a P value = 0.563. R1 on the right side showed that in orthognathic maxilla, CU was more common followed by DIV =ST>WA>CO>CI shapes. In prognathic ST>DIV>CU>WA=CO>CI was the order & in retrognathic the pattern was DIV>ST>CU>WA >CO with no sample showing CI pattern and this difference in pattern was statistically insignificant as shown by a P value = 0.717.

The frequency distribution of different shapes of R2 in all the 3 groups for both left and right side are shown in table 29 and 30 respectively. Chi-square results are shown in table 31 and 32 for the left and right side respectively. Fig. 10 and 11 shows the diagrammatic representation of the same respectively. R2 on the left side showed that in orthognathic maxilla, WA was more common followed by CU>ST>DIV and no sample showed CO pattern. In prognathic it was in the following order- WA>CU>DIV=ST>CO & in retrognathic, the pattern was found to be found to be WA>CU>ST>DIV>CO. No sample in all 3 groups had shown CI pattern and this difference in pattern was statistically insignificant shown by a P value = 0.534. R2 on the right side showed that in orthognathic maxilla, WA was more common followed by ST>CU>DIV>CO. In prognathic following pattern was seen- WA>CU=ST>DIV and in retrognathic it was WA>CU>ST>DIV. No sample in all 3 groups showed CI pattern and CO pattern was missing in prognathic & retrognathic maxilla and this difference in pattern was statistically insignificant as shown by a P value = 0.222.

The frequency distribution of different shapes of R3 in all the 3 groups for both left and right side are shown in table 33 and 34 respectively. Chi-square results are shown in table 35 and 36 for the left and right side respectively. Fig. 12 and 13 shows the diagrammatic representation of the same respectively. R3 on left side showed that in orthognathic maxilla, WA was more common followed by CU>DIV>ST and no sample showed CO pattern. In prognathic it was found in the following order- WA>CU>DIV=ST and no sample showed co pattern and in retrognathic it was found to be WA>CU>ST=DIV>CO. No sample in all 3 groups had shown CI pattern and this difference in pattern was statistically insignificant as evident by a P value = 0.695. R3 on right side showed that in orthognathic maxilla, WA was more common

followed by CU>ST>DIV>CO. In prognathic it was in the following order- WA>CU>ST and in retrognathic it was found to be WA>CU>ST>DIV. No sample in all 3 groups showed CI pattern. CO pattern was missing in both prognathic & retrognathic maxilla and DIV pattern was missing only in prognathic maxilla and this difference in pattern was statistically insignificant as evident by a P value = 0.581.

The frequency distribution of different shapes of R4 in all the 3 groups for both left and right side are shown in table 37 and 38 respectively. Chi-square results are shown in table 39 and 40 for the left and right side respectively. Fig. 14 and 15 shows the diagrammatic representation of the same respectively. R4 on the left side showed that in orthognathic maxilla, WA was more common shape followed by CU>ST >CO and DIV pattern was not found. In prognathic WA>CU>ST was the order & no sample showed CO and DIV pattern and in retrognathic, the pattern was found to be WA>CU>ST>DIV and CO was found missing. No sample in all 3 groups showed CI pattern and this difference in pattern was statistically insignificant as shown by a P value = 0.855. R4 on the right side showed that in orthognathic maxilla, WA was more common followed by ST>CU >CO and DIV was found missing. In prognathic maxilla, it was in the following order- WA>CU>ST and no sample showed CO and DIV pattern. In retrognathic WA>CU=ST>DIV>CO was the order. No sample in all 3 groups showed CI pattern and this difference in pattern was statistically insignificant as shown by a P value = 0.847.

The frequency distribution of different shapes of R5 in all the 3 groups for both left and right side are shown in table 41 and 42 respectively. Chi-square results are shown in table 43 and 44 for the left and right side respectively. Fig. 16 and 17 shows the diagrammatic representation of the same respectively. On the left side no group

showed DIV ,CO and CI pattern for R5. In orthognathic maxilla, only WA pattern was found and all other pattern found to be absent. In prognathic maxilla, it was the order-WA>ST>CU and in retrognathic order was found to be WA>ST and CU was missing. This difference in pattern was statistically insignificant as shown by a P value = 0.411. On the right side no group showed DIV, CO and CI pattern for R5. In orthognathic maxilla, pattern was WA>CU=ST. In prognathic maxilla, it was WA=ST, CU was missing and in retrognathic only WA pattern was found. This difference in pattern was statistically insignificant as shown by a P value = 0.78.

DISCUSSION

The palatal rugae, the transverse ridges situated in the anterior part of the palatine mucosa, are widely present in mammals, but their biological significance is little understood. The development of rugae could be coordinated with that of the palate as a whole. There also could be an association of ridge development with the size of palate which, it is suggested, reflects local differences in rate of cell division in early embryonic life. English WR et al 1988[11] quoted in their article that palatal rugae (PR) or transverse palatine folds, refer to the irregular elevations of the mucous membrane extending laterally from the incisive papilla and the anterior part of the median palatal raphe located in the mid-sagittal plane. The core fibres running anteroposteriorly in concentric circles below each rugae govern the orientation and forms of palatal rugae. Beneath the thickened epithelium fibroblasts and collagen fibres then accumulate in the connective tissue and assume distinct orientation. The core within the palatal rugae of humans contains elements that are believed to contribute to the maintenance of its shape. Glycosaminoglycans are the main structural element of the rugae which by its hydrophilic nature causes the tissue to swell and contributes to the maintenance of the shape of a rugae throughout life.

Hermosilla v. v. et al, 2009[77] quoted that the palatal rugae appear during the third month of intrauterine life from the connective tissue covering the palatine process of the maxillary bone. The growth and development is controlled by epithelial-mesenchymal interactions, where specific extracellular matrix molecules are

spatiotemporally expressed during development[3]. The first rugae is distinguished in human embryos of 32 mm CRL [4] next to the incisive papilla. In the prenatal stage the rugae are relatively prominent[56], the PR at birth are well trained with a typical orientation pattern[5] and adolescence acquire the final feature shape of each individual[7]. Once formed, they may experience changes in their size due to growth of the palate, but its shape will be maintained[8,9].

Histologically, the rugae are stratified squamous (layered scales), mainly parakeratinized, epithelium on a connective tissue base, similar to the adjacent tissue of the palate[10]**.**

Among the common methods used in the forensic sciences for confirming the identity are fingerprinting, DNA analysis and dental comparison. In forensic dentistry, the oral cavity plays a very important role because of unique anatomy of teeth. In certain situations, if teeth are lost due to any reason, the most common of which is trauma, then the use of human palatal rugae has been suggested as an alternative method for identification.

The palatal rugae like fingerprints do not change during the life of an individual, and are protected from trauma and high temperatures because of its internal position in the oral cavity where they are surrounded and protected by lips, cheeks, tongue, teeth and bone. Once formed, they change only in their length, due to normal growth, and remain stable in the same position throughout the life of a person. They even reappear after trauma or surgical procedures.

Many studies have shown that these rugae have significant characteristics features that they are unique patterns in each individual. Even panfacial

third degree burns will not produce any changes in palatal rugae pattern which was reported in the study of Muthusubramanian M. et al, 2005 [13]. Authors like Bansode,et al 2009[10], D. Shukla et al 2011[67] and Anukool H. et al,2011[68] have reported that fixed orthodontic treatment causes dental changes and sometimes bony changes , but produces no changes in the rugae pattern which again confirms the stability and uniqueness of the palatal rugae. Various computerized techniques have also proved the individualistic characteristics of palatal rugae in the studies of Hemanth M et al,2010[78] and Rezwana Begum Mohammed et al,2013[79].

The study of palatal rugae, finds application in the field of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics and orthodontics termed as Rugoscopy.

The palatal rugae have interested orthodontists not only because of their typical pattern of orientation but also because of their usefulness as a reference landmark in various dental treatment modalities. Numerous literatures quote the evidence of significant association between rugae pattern and ethnicity, gender, and orthodontic treatment.

Searching various literatures it was found that malocclusion have been related to dermatoglyphics (the study of fingerprints) and cheiloscopy (the study of lip prints) in the studies of the following authors. Reddy et al,1997[80] conducted a study using dermatoglyphics (study of finger prints) to compare and predict Class I, Class II, div. 1, div.2 and Class III malocclusions. According to them, dermatoglyphics is the study on epidermal ridges on the palmar and plantar surfaces of the feet and hand. Embryological development of orodental structures and these dermal patterns occur during the same

period. The environmentally influenced genetic predisposition is found in different types of malocclusions. This malocclusion should also exhibit different dermal patterns which are unique for each class. They found significant relationship between finger prints and malocclusion. Another study was conducted by Tikare et al,2010[81] to assess the relationship between fingerprints and malocclusion. The authors found a statistical association between whorl patterns and classes I and II malocclusion ($p<0.05$). However, no overall statistical association was observed between fingerprint patterns and malocclusion ($p>0.05$).

Kulkarni N et al,2012[82] were first to evaluate any relationship between cheiloscopy and malocclusion. Based on lip prints, skeletal class I and class III could be identified more expediently in comparison to skeletal class II. The study had shown that lip prints could be employed for sagittal jaw relation recognition. Pradeep Raghav et al,2013 [83] assessed the utility of lip prints by comparative evaluation of lip patterns among subjects having different skeletal malocclusions (class I, class II and class III). A definite co‑relation of vertical lip patterns with skeletal class III malocclusion was revealed.

The study of palatine rugae and the study of fingerprints (dermatoglyphics) and lip prints (cheiloscopy) are sometimes complementary as they operate in similar methods based on same scientific basis. Since searching literature did not yield many studies relating palatal rugae to the malocclusion, this study was initiated with an aim to evaluate the relationship of rugae with different maxillary anteroposterior dysplasia.

The present study was conducted as a cross-sectional study (prevalence study) which is simplest, relatively easy and economical to execute. A representative sample size of 30 of the general population in the age group of 15-25 yrs. was collected for each group. Sample size of 30 was chosen to minimize sample variability and to allow estimates of the population characteristics to be made with measurable precision.

Age group of 15-25yrs was considered in the present study as growth will not change the number ,size and shape of the rugae with time as supported by Yamazaki, 1962[7] who stated that each individual acquire the final feature shape of PR in adolescence. Van der Linden FP, 1978[26] has also proved that the anterior rugae do not increase in length after 10 years of age . As the study aimed to evaluate the relationship between palatal rugae and different maxillary APD, it was carried out on maxillary dental cast which harbors rugae on its anterior third of palate behind the incisive papilla. Samples were divided into 3 groups- orthognathic, prognathic and retrognathic group which consisted of collected maxillary casts based on the certain cephalometric criteria's. Steiner's SNA and Mcnamara's N$\underline{l}$A parameters were noted for maxilla. All the 3 groups were having orthognathic mandible based on cephalometric parameters like Steiner's SNB, SND and McNamara's pog N$\underline{l}$.

Finger sucking in childhood, congenital anomalies/malformations, previous orthognathic surgery, orthodontic treatment, deformity or scars and trauma of the palate were excluded because there are possibilities of changes in PR pattern as supported by Lysell L, 1955[16] who in his study found that some events can contribute to changes in rugae pattern, including trauma, extreme finger sucking in infancy, and

persistent pressure with orthodontic treatment and dentures. Kapali et al ,1997[14] also supported the above statement. Similarly Simmons JD, Moore RN, Erickson LC 1987[27] noted that rugae count decreases significantly following cleft repair and median rugae region increases in anteroposterior length with growth, these changes are more obvious in orthodontically treated cases.

PR pattern has been categorized into different classifications based on their shape, size, number, direction of arrangement etc. by different people to be used for forensic identification. Literature has documented numerous classifications, for eg. Goria , Trobo Hermosa, Carrea , Da Silva , Thomas and Kotze, Kapali Et Al, Martins Dos Santos, Basauri Classification. In this study classification suggested by Thomas and Kotze et al (1983) [20]and Kapali et al (1997)[14] for recording palatal rugae pattern had been used. These classifications were chosen because these were simple and easy to apply when compared to other methods such as those of Hauser et al[62] and of Reuer[60].

Assessment of palatal rugae by photographic method is the most commonly used one in most of the studies but this method accounts for magnification errors which will not give reliable dimensions for the size of the rugae. The present study also needed a more detailed and accurate data for future comparison and analysis, and the need to preserve evidences may justify the use of casts which is also supported by Utsuno et al, 2005[84]. Though observing the shape of the rugae is a subjective process, it is relatively easy to record and does not require advanced training and complex instrumentations to assess palatal rugae pattern using this method. It also serves as a reliable guiding tool when future comparisons are to be made. This is also supported by Sognnaes[85] who suggest the use of cast made from jaws rather than the

dentures for a more accurate result. Similarly, the study of Jacob and Shalla[86] reported 100% accuracy on evaluation of the entire cast while only 79 percent accuracy on evaluating the rugae tracing. Thus their study insisted on the use of entire cast topography. Hence in the present study, maxillary dental casts with manual tracing were used to study the rugae pattern. The method used in this study was also in accordance with the method used in the studies of Bajracharya D et al[87], Byatnal et al[76] and A. Saraf et al[88].

With regard to the number, in this study, all the 3 groups showed more propensities for 4 rugae on both right and left side. On the left side prognathic maxilla had shown more samples with 3 rugae pattern when compared to the other two groups but this was not statistically significant.

On the right side, prognathic maxilla and retrognathic maxilla showed more samples with 4 rugae number and orthognathic maxilla showed more samples with 5 rugae number. This was found to be statistically significant with a p value of 0.034. Since no similar studies relating PR to the size of maxilla has been done, these results could not be compared. These result could be correlated with Kallianpur, S., Desai, et al,2011[73] study who also reported more number of rugae on the right side than the left side in Indian population but not comparable to the studies of Dohke and Osato(1994)[70] who reported that numbers of the rugae on the right side were fewer than on the left side in the Japanese population.

With regard to the size of the rugae, the present study has not shown any statistically significant difference in any of the 3 groups. Since no similar

studies relating PR to the size of maxilla had been done, these results also could not be compared.

On observation, it was found that R1, on both left and right sides were longest in prognathic maxilla and shortest in retrognathic. This may attribute to the bigger size of the maxilla in prognathic and smaller size in the retrognathic maxilla. This was in accordance with the study done by Hauser et al in 1989[62] who stated that the size of the palate affected rugae development. They reported that individuals with broader palates showed greater rugae development. Our results were not comparable to Gandikota et al,2012[89] study who showed that the first palatal rugae were shorter in class II div 1 patients than in class I patients. This may be due to the reason that the authors had considered class II and not the size of maxilla and class II which can be either due to retrognathic mandible or prognathic maxilla.

R2 showed different patterns on both right and left sides. On the left side, R2 was longest for prognathic maxilla and shortest for the retrognathic same as that of R1. On the right side, R2 was longest for orthognathic and shorter for both prognathic and retrognathic maxilla with similar mean value. Right side results were comparable to Gandikota et al,2012[89] study who showed that the second palatal rugae were shorter in class II div 1 patients than in class I patients.

R3 on both left and right sides were longest for orthognathic, shorter for prognathic and shortest for retrognathic maxilla. This result was comparable to Gandikota et al,2012[89] study who showed that the third palatal rugae were shorter in class II div 1 patients than in class I patients. They concluded that shorter R3 attributes to the constriction of the arch in class II div 1 individuals than in class I individuals.

R4 and R5 showed similar pattern on the same sides. On the left side the order was found to be orthognathic> retrognathic> prognathic. On the right side it was prognathic> retrognathic>orthognathic.

With regard to the shape of the rugae, in the present study, it was found that the wavy type was the most predominant shape followed by curved in all the 3 groups for all rugae except R1. R1 didn't show any noticeable pattern. This was in accordance with some of the studies like Amit Byatnal et al ,2014[76]**,** study done on five states of India to find the frequency distribution of different rugae shapes who also found the same results in Tamilnadu population.

This was also comparable to the study carried out by Kapali et al,1997[14] who had found that the most common shapes in both Australian Aborigines and whites ethnic groups were wavy and curved forms . Nayak et al, 2007[31] also showed the same results in a study done on two populations of India. Kallianpur S., Desai et al,2011[73]In their study, also observed that the predominant shape of palatal rugae seen in Indian population was wavy type followed by curved type.

The present study results were not comparable to the Rai et al,2007 [71]study who showed that the straight type rugae were more common in North Indian population since we did not include any North Indian population as study group sample. Prognathic group showed more converging pattern for R1 on both left and right sides and more diverging pattern for R2 on both sides when compared to the other two groups but this finding was not statistically significant.

Retrognathic maxilla had shown more curved pattern than other two groups for R2 and R3 on right side but this result was also not statistically significant.

Orthognathic maxilla had shown more diverging pattern when compared to other two groups for R3 in both left and right sides, but was not statistically significant.

This study could not find any specific noticeable pattern for R4 and R5.

Thus, this study showed a significant difference among the three groups with respect to the number of rugae on the right side. No significant difference was found in the size of rugae among three groups. Wavy type was the most common type found among the three groups followed by curved type.

SUMMARY AND CONCLUSION

The knowledge of biological significance of palatal rugae is an area which needs to be explored more. Studies have revealed that the rugae pattern is unique and stable for each individual. Rugoscopy, the study to establish individual's identity, finds application in various fields like anthropology, genetics, forensic odontology, and orthodontics. Orthodontists use palatal rugae as a reference landmark in various dental treatment modalities because of their typical pattern of orientation. Few studies have found significant correlation between palatal rugae pattern and malocclusion so an attempt was made to evaluate the uniqueness of palatal rugae in different maxillary anteroposterior dysplasia. The present study was conducted as a cross-sectional study with sample size of 30 in the age group of 15-25 yrs. was collected for each group. The pattern in relation to the number, size and shape of rugae were statistically analyzed and the following conclusions are arrived at.

- Statistically significant differences were observed in relation to number of the rugae on the right side and the size of maxilla. Prognathic and retrognathic maxilla were observed to have more propensities for 4 rugae compared to othognathic. Orthognathic maxilla was found to show more inclination towards 5 numbers. No statistically significant differences were established on the left side.
- Though no statistical significance was observed with regard to the shape or size of the rugae and the size of maxilla, some observational findings are listed below-

- First rugae on both left and right sides were longest in prognathic maxilla and shortest in retrognathic. This may attribute to the bigger size of the maxilla in prognathic and smaller size in retrognathic maxilla.
- Second rugae did not show any noticeable pattern.
- Third rugae on both left and right sides were longest for orthognathic ,shorter for prognathic and shortest for retrognathic maxilla. This may be attributed to the constriction of arches posteriorly in prognathic and retrognathic maxilla.
- Wavy was the most predominant shape followed by curved in all the 3 groups for all rugae except the first rugae.
- Prognathic group showed more converging pattern for R1 on both left and right sides and more diverging pattern for R2 on both sides when compared to other two groups.
- Retrognathic maxilla had shown more curved pattern than other two groups for R2 and R3 on right side.
- Orthognathic maxilla had shown more diverging pattern when compared to other two groups for R3 in both left and right sides.

Rugoscopy has been used as an important adjunct in the field of forensic sciences for human identification. Observations made in this study revealed statistically significant correlation between rugal number on the right side and the size of maxilla, although the parameters like size and shape of the rugae exhibited no statistically significant finding. Thus, maxillary anteroposterior dysplasia is found to have some correlation with rugal pattern but it is too premature to make a comment on the use of

palatal rugae as an additional criterion to classify malocclusions. Larger samples should be examined in detail to further validate the observational findings of this study for definitive conclusions. To conclude, palatal rugae hold potential as a supplementary tool to establish the identity of an individual.

BIBLIOGRAPHY

1. Goria, C. (1955). Le rughe del palato in speciale rapporto coll anthropologia criminale e la psichiatria. 1911. Cited by: Lysell L. Plicae palatinae transversae and papilla incisiva in man. Acta Odontol Scand, 13, 5-137.

2. Carrea JU(1937). La Identificacion humana por las rugosidades palatinas. Rev Orthodont (Buenos Aires),1,3-23.

3. Amasaki, H., Ogawa, M., Nagasao, J., Mutoh, K. I., Ichihara, N., Asari, M., & Shiota, K. (2003). Distributional changes of BrdU, PCNA, E2F1 and PAL31 molecules in developing murine palatal rugae. Annals of Anatomy-Anatomischer Anzeiger, 185(6), 517-523.

4. BUCHTOVA, M., TICHY, F., PUTNOVA, I., & MISEK, I. (2003). The development of palatal rugae in the European pine vole, Microtus subterraneus (Arvicolidae, Rodentia). Folia zoologica, 52(2), 127-136.

5. GEGENBAUR, C. (1878). Die Gaumenfalten des Menschen. Morphologisches Jahrbuch 4, 573-583.

6. Waterman, R. E., & Meller, S. M. (1974). Alterations in the epithelial surface of human palatal shelves prior to and during fusion: a scanning electron microscopic study. The Anatomical Record, 180(1), 111-135.

7. Yamazaki, Y. (1962b). Cross-sectional study of plicae palatinae transversae in the Japanese. Anthropological Reports Niigata 34, 59-76.

8. Jordanov, J. A. (1971). Growth of the hard palate in man. Anthropological characteristics. Z Morphol Anthropol,63(2), 230.

9. Lang, J., & Baumeister, R. (1984). Postnatale Entwicklung der Gaumenbreite und-höhe und die Foramina palatina. Anat Anz Jena, 155, 151-167.

10. Bansode, S. C., & Kulkarni, M. M. (2009). Importance of palatal rugae in individual identification. Journal of Forensic Dental Sciences, 1(2), 77.

11. English, W. R., Robison, S. F., Summitt, J. B., Oesterle, L. J., Brannon, R. B., & Morlang, W. M. (1988). Individuality of human palatal rugae. Journal of forensic sciences, 33(3), 718-726.

12. Thomas, C. J., Kotze, T., & Van der Merwe, C. A. (1987). An improved statistical method for the racial classification of man by means of palatal rugae.Archives of oral biology, 32(4), 315-317.

13. Muthusubramanian, M.; Limson, K. S. & Julian, R.(2005). Analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition. J. Forensic Odontostomatol., 23(1),26-9.

14. Kapali, S., Townsend, G., Richards, L., & Parish, T. (1997). Palatal rugae patterns in Australian Aborigines and Caucasians. Australian dental journal,42(2), 129-133.

15. Peavy Jr, D. C., & Kendrick, G. S. (1967). The effects of tooth movement on the palatine rugae. The Journal of prosthetic dentistry, 18(6), 536-542.

16. Winslow, J. B. (1732). Exposition anatomique de la structure du corps humain . Cited by: Lysell L. Plicae palatinae transversae and papilla incisiva in man. Acta Odontol Scand, 13, 5-137.

17. Santorini, G. D. (1775). Anatomici summi septemdecim tabulae. cited by: Lysell, L. (1955). Plicae palatinae transversae and papilla incisiva in man; a morphologic and genetic study. Acta odontologica scandinavica, 13(Suppl. 18), 5.

18. Patil, M. S., Patil, S. B., & Acharya, A. B. (2008). Palatine rugae and their significance in clinical dentistry: a review of the literature. Journal of the American Dental Association (1939), 139(11), 1471-1478.

19. CARREA, J. (1955). Fotostenograms of palate folds, a new identification technic. Deutsche zahnärztliche Zeitschrift, 10(1), 11.

20. Thomas, C. J., & Kotze, T. J. (1983). The palatal ruga pattern: a new classification. The Journal of the Dental Association of South Africa, 38(3), 153.

21. Caldas, I. M., Magalhães, T., & Afonso, A. (2007). Establishing identity using cheiloscopy and palatoscopy. Forensic science international, 165(1), 1-9.

22. Kashima, K. (1990). [Comparative study of the palatal rugae and shape of the hard palatal in Japanese and Indian children]. Aichi Gakuin Daigaku Shigakkai Shi, 28(1 Pt 2), 295-320.

23. Shetty, S. K., Kalia, S., Patil, K., & Mahima, V. G. (2004). Palatal rugae pattern in Mysorean and Tibetan populations. Indian journal of dental research: official publication of Indian Society for Dental Research, 16(2), 51-55.

24. Almeida, M. A., Phillips, C., Kula, K., & Tulloch, C. (1995). Stability of the palatal rugae as landmarks for analysis of dental casts. The Angle Orthodontist, 65(1), 43-48.

25. Lysell, L. (1955). Plicae palatinae transversae and papilla incisiva in man; a morphologic and genetic study. Acta odontologica scandinavica, 13(Suppl. 18), 5.

26. van der Linden, F. P. (1978). Changes in the position of posterior teeth in relation to ruga points. American journal of orthodontics, 74(2), 142-161.

27. Simmons, J. D., Moore, R. N., & Erickson, L. C. (1987). A longitudinal study of anteroposterior growth changes in the palatine rugae. Journal of dental research, 66(9), 1512-1515.

28. Hauser, G., Daponte, A., & Roberts, M. J. (1989). Palatal rugae. Journal of anatomy, 165, 237.

29. Bailey, L. T. J., Esmailnejad, A., & Almeida, M. A. (1996). Stability of the palatal rugae as landmarks for analysis of dental casts in extraction and nonextraction cases. The Angle Orthodontist, 66(1), 73-78.

30. Abdel-Aziz, H. M., & Sabet, N. E. (2000). Palatal rugae area: a landmark for analysis of pre-and post-orthodontically treated adult Egyptian patients. Eastern Mediterranean health journal, 7(1-2), 60-66.

31. Nayak, P., Acharya, A. B., Padmini, A. T., & Kaveri, H. (2007). Differences in the palatal rugae shape in two populations of India. Archives of oral biology,52(10), 977-982.

32. Harrison, A. (1889). The palatal rugae in man. Proc Acad Nat Soc, 6, 245.

33. Pueyo VM, Garrido BR, Sanchez JA. (1994). Odontologialegal. Forense, Masson, B. p. 277-92.

34. Limson, K. S., & Julian, R. (2004). Computerized recording of the palatal rugae pattern and an evaluation of its application in forensic identification. The Journal of forensic odonto-stomatology, 22(1), 1-4.

35. Acharya AB, Sivapathasundharam B. Forensic Odontology(2006). In: Rajendran R, Sivapathasundharam B. Eds. Shafer′s Textbook of Oral Pathology. Fifth Edn. Elsevier, New Delhi, p. 1199-227.

36. Krishnappa S, Srinath S, Bhardwaj P, CH Mallaya(2013. Palatal Rugoscopy: Implementation in Forensic Odontology- A Review. J Adv Med Dent Scie;1(2),53-59.

37. Swetha SK, Kalia S, Patil K, Mahima VG(2005). Palatal rugae pattern in Mysorean and Tibetan populations. Indian J Dent Res,16,51-5.

38. Indira, A. P., Gupta, M., & David, M. P. (2011). Rugoscopy for establishing individuality. Indian J Dent Adv, 3, 427-32.

39. Surekha, R., Anila, K., Reddy, V. S., Hunasgi, S., Ravikumar, S., & Ramesh, N. (2012). Assessment of palatal rugae patterns in Manipuri and Kerala population. Journal of forensic dental sciences, 4(2), 93.

40. Goyal, S., & Goyal, S. (2013). STUDY OF PALATAL RUGAE PATTERN OF RWANDAN PATIENTS ATTENDING THE DENTAL DEPARTMENT AT KING FAISAL HOSPITAL, RWANDA: A PRELIMINARY STUDY. Rwanda Med J ,70,19-25.

41. Sassouni, V. (1957). Palatoprint, Physioprint, and Roentgenographic Cephalometry, as New Methods in Human Identification: Preliminary Report. Callaghan. J Forensic Sciences,2,428-42.

42. DAHLBERG, A. (1963). CONFERENCE ON GENETIC ASPECTS OF ORAL STRUCTURES. INTRODUCTION. Journal of dental research, 42, SUPPL1260-1.

43. Fiene, M. (1958). Vergleichend-morphologische Studien über das Gaumenfaltenrelief von Zwillingen. Fortschritte der Kieferorthopädie, 19(3), 229-236.

44. Morlang, W. M. (1982). Forensic dentistry. Aviation, space, and environmental medicine, 53(1), 27-34.

45. Campos, M. L. Rugoscopia palatine..

46. Thomas, C. J., & Van Wyk, C. W. (1988). The palatal rugae in an identification. J Forensic Odontostomatol ,6,21-7.

47. Fahmi, F. M., Al-Shamrani, S. M., & Talic, Y. F. (2001). Rugae pattern in a Saudi population sample of males and females. Saudi dental journal, 13(2), 92-95.

48. Kamala, R., Gupta, N., Bansal, A., & Sinha, A. (2011). Palatal Rugae Pattern as an Aid for Personal Identification: A Forensic Study. Journal of Indian Academy of Oral Medicine & Radiology, 23(3).

49. Snow GB (1889) The proper configuration of the lingual surfaces of dental plates. 20, 51-54.

50. Landa, J. S. (1935). The importance of phonetics in full denture prosthesis. D. Digest, 41, 154-160.

51. Moses Jr, E. R. (1940). A brief history of palatography. Quarterly Journal of Speech, 26(4), 615-625.

52. Bloomer, H. H. (1943). A palatograph for contour mapping of the palate. Journal Amer. Dental Association, 30, 1053.

53. Pound, E. (1951). Esthetic dentures and their phonetic values. The Journal of prosthetic dentistry, 1(1), 98-111.

54. Silverman, M. M. (1967). The whistle and swish sound in denture patients. The Journal of prosthetic dentistry, 17(2), 144-148.

55. Chierici, G., & Lawson, L. (1973). Clinical speech considerations in prosthodontics: perspectives of the prosthodontist and speech pathologist. The Journal of prosthetic dentistry, 29(1), 29-39.

56. Gitto, C. A., Esposito, S. J., & Draper, J. M. (1999). A simple method of adding palatal rugae to a complete denture. The Journal of prosthetic dentistry, 81(2), 237-239.

57. Park, S., Eguti, T., Kato, K., Nitta, N., & Kitano, I. (1994). The pattern of palatal rugae in submucous cleft palates and isolated cleft palates. British journal of plastic surgery, 47(6), 395-399.

58. Kratzsch, H., & Opitz, C. (2000). Investigations on the Palatal Rugae Pattern in Cleft Patients Part II: Changes in the Distances from the Palatal Rugae to Maxillary Points. Journal of orofacial orthopedics/Fortschritte der Kieferorthopädie, 61(6), 421-431.

59. Ikemi, N., Otani, Y., Ikegami, T., & Yasuda, M. (2000). Palatal ruga anomaly induced by all-< i> trans</i>-retinoic acid in the Crj: SD rat: possible warning sign of teratogenicity. Reproductive Toxicology, 15(1), 87-93.

60. Reuer, E. (1973). Gaumentleistein und Gaumerferm bei drei lokalen populationen in Osterreich. Mitteilungen der Anthropologischen Gesellschaft in Wien, 103, 1-3.

61. Bailey, L. T. J., Esmailnejad, A., & Almeida, M. A. (1996). Stability of the palatal rugae as landmarks for analysis of dental casts in extraction and nonextraction cases. The Angle Orthodontist, 66(1), 73-78.

62. Hauser, G., Daponte, A., & Roberts, M. J. (1989). Palatal rugae. Journal of anatomy, 165, 237-249.

63. Hoggan, B. R., & Sadowsky, C. (2001). The use of palatal rugae for the assessment of anteroposterior tooth movements. American Journal of Orthodontics and Dentofacial Orthopedics, 119(5), 482-488.

64. Christou, P., & Kiliaridis, S. (2008). Vertical growth-related changes in the positions of palatal rugae and maxillary incisors. American journal of orthodontics and dentofacial orthopedics, 133(1), 81-86.

65. Damstra, J., Mistry, D., Cruz, C., & Ren, Y. (2009). Antero-posterior and transverse changes in the positions of palatal rugae after rapid maxillary expansion. The European Journal of Orthodontics, 31(3), 327-332.

66. Jang, I., Tanaka, M., Koga, Y., Iijima, S., Yozgatian, J. H., Cha, B. K., & Yoshida, N. (2009). A novel method for the assessment of three-dimensional tooth movement during orthodontic treatment. The Angle Orthodontist, 79(3), 447-453.

67. Shukla, D., Chowdhry, A., Bablani, D., Jain, P., & Thapar, R. (2011). Establishing the reliability of palatal rugae pattern in individual identification (following orthodontic treatment). J Forensic Odontostomatol, 29(1), 20-9.

68. Pateria, A., & Thakkar, K. (2011). Palatal rugae a stable landmark-A comparison between pre and post orthodontic patients. International Journal of Dental Clinics, 3(4).

69. Dr. M Kulkarni, Dr.P.Gore(20130. To study the changes in the palatine rugae pattern during various orthodontic treatment. J. Forensic Med. Sci. Law 22.

70. Dohke M and Osato S(1994). Morphological study of the palatal rugae in Japanese1. Bilateral differences in the regressive evaluation of the palatal rugae. Jap J Oral Biol,36,125-40

71. Rai, B., & Anand, S. C. (2007). Palatal rugae: In forensic examination. Indian Internet Journal of Forensic Medicine & Toxicology, 5(1), 14-16.

72. Paliwal, A., Wanjari, S., & Parwani, R. (2010). Palatal rugoscopy: Establishing identity. Journal of forensic dental sciences, 2(1), 27.

73. Kallianpur, S., Desai, A., Kasetty, S., Sudheendra, U. S., & Joshi, P. (2011). An anthropometric analysis of facial height, arch length, and palatal rugae in the Indian and Nepalese population. Journal of forensic dental sciences,3(1), 33.

74. Manjunath, S., Bakkannavar, S. M., Kumar, P., Bhat, V. J., Prabhu, N., Kamath, A., & RaghavendraBabu, Y. P. (2012). Palatal rugae patterns among the Indians at Manipal, India. Journal of Pharmaceutical and Biomedical Sciences, 20(20), 1-5.

75. Madhankumar, S., Natarajan, S., Maheswari, U., Anand, V., Padmanabhan, T., & Fathima, B. (2013). Palatal rugae pattern for gender identification among selected student population in Chennai, India. Journal of Scientific Research and Reports, 2(2), 491-496.

76. Byatnal, A., Byatnal, A., Kiran, A. R., Samata, Y., Guruprasad, Y., & Telagi, N. (2014). Palatoscopy: An adjunct to forensic odontology: A comparative study among five different populations of India. Journal of natural science, biology, and medicine, 5(1), 52.

77. Palatinas, R., & de su Forma, S. D. A. (2009). Palatal rugae: Systematic analysis of its shape and dimensions for use in human identification. Int. j. morphol, 27(3), 819-825.

78. Hemanth, M., Vidya, M., Shetty, N., & Karkera, B. V. (2010). Identification of individuals using palatal rugae: Computerized method. Journal of forensic dental sciences, 2(2), 86-90.

79. Mohammed, R. B., Patil, R. G., Pammi, V. R., Sandya, M. P., Kalyan, S. V., & Anitha, A. (2013). Rugoscopy: Human identification by computer-assisted photographic superimposition technique. Journal of forensic dental sciences, 5(2), 90-95.

80. Reddy S, Prabhakar AR, Reddy VV(1997). A dermatoglyphic predictive and comparative study of Class I, Class II, div. , div.2 and Class III malocclusions. J Indian Soc Pedod Prev Dent,15,13-19.

81. Tikare, S., Rajesh, G., Prasad, K. V. V., Thippeswamy, V., & Javali, S. B. (2010). Dermatoglyphics—A marker for malocclusion?. International dental journal, 60(4), 300-304.

82. Kulkarni, N., Vasudevan, S. D., Shah, R., Rao, P., & Balappanavar, A. Y. (2012). Cheiloscopy: A new role as a marker of sagittal jaw relation. Journal of forensic dental sciences, 4(1), 6-12.

83. Raghav, P., Kumar, N., Shingh, S., Ahuja, N. K., & Ghalaut, P. (2013). Lip prints: The barcode of skeletal malocclusion. Journal of forensic dental sciences, 5(2), 110.

84. Utsuno, H., Kanoh, T., Tadokoro, O., & Inoue, K. (2005). Preliminary study of post mortem identification using lip prints. Forensic science international,149(2), 129-132.

85. Sognnaes, R. D. (1977). Forensic stomatology (third of three parts). The New England journal of medicine, 296(4), 197-203.

86. Jacob, R. F., & Shalla, C. L. (1987). Postmortem identification of the edentulous deceased: denture tissue surface anatomy. Journal of forensic sciences, 32(3), 698-702.

87. Bajracharya, D., Vaidya, A., Thapa, S., & Shrestha, S. (2014). Palatal Rugae Pattern in Nepalese Subjects. Orthodontic Journal of Nepal, 3(2), 36-39.

88. Saraf, A., Bedia, S., Indurkar, A., Degwekar, S., & Bhowate, R. (2011). Rugae patterns as an adjunct to sex differentiation in forensic identification. J Forensic Odontostomatol, 29(1), 14-19.

89. Gandikota, C., Venkata, Y. P., Challa, P., Juvvadi, S. R., & Mathur, A. (2012). Comparative study of palatal rugae pattern in class II div 1 and class I individuals. Journal of pharmacy & bioallied sciences, 4(Suppl 2), 358-363.